Appendix G7
Air Quality - Air Quality Analyses of Operating and FSRU Startup Emissions - Criteria Air Pollutants

G7-1 California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal

G7-2 Air Quality Impact Assessment of the Startup Operations at the BHP Cabrillo Deepwater Port LNG Import Terminal

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G7-1
California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal

sierra research

California Environmental Quality Act Air Quality Impact Assessment of the BHP Cabrillo Deepwater Port LNG Import Terminal

prepared for:

BHP Billiton

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prepared by:

Sierra Research, Inc.
1801 J Street
Sacramento, California 95814
(916) 444-6666

SUMMARY

BHP Billiton LNG International, Inc. (BHP), EPA Region IX (EPA), and the California State Lands Commission (State Lands) are currently assessing the impacts of the proposed Cabrillo Port Offshore LNG Import Terminal (Cabrillo Port). An ambient air impacts analysis was prepared as part of the December 30, 2003 permit application. The modeling has been refined several times to reflect improved project design elements and additional refinements to the analysis that were requested by EPA and other reviewers. The following modeling analysis was prepared to update the ambient air impacts analysis to reflect BHP's latest refinements to the emission rates and operating assumptions.[1]

The modeling analysis is based on predicted maximum Cabrillo Port emissions. NOx, SO_2, CO, and $PM_{10}/PM_{2.5}$ emissions from the stationary sources (including the support vessels and LNG carriers in District and Federal waters) were modeled using the EPA-approved Offshore and Coastal Dispersion (OCD) Model. The overwater receptor grid extended approximately 22 miles up and down the coast from the FSRU. The overland receptor grid extended two miles inland from the shoreline between Oxnard and Point Dume, and receptors were also placed at 100 meter intervals along the shoreline from Point Dume to the Palos Verdes Peninsula in the South Coast Air Basin (SoCAB). Worst-case impacts were determined at both onshore and offshore receptors. Ambient impacts at the worst-case onshore receptor for each pollutant were well below the federal significance thresholds. For example, NO_2 and PM_{10} levels at the worst-case onshore receptor are expected to be less than five percent of the applicable significance thresholds. Based upon this modeling, Cabrillo Port will not materially impact onshore air quality and will not cause or contribute to onshore ambient air quality standard violations.

1.0 AIR QUALITY IMPACT ANALYSIS

1.1 AIR QUALITY MODELING METHODOLOGY

As for the original air quality impact analysis performed for the project in the permit application, this update to the air quality impact analysis used the OCD Model. The offshore meteorological data set used by the model is identical to that used in the December 2005 air quality impact analysis, and had previously been expanded and updated from the three-year data set originally used.[2] The meteorological data set consists of data collected during 2000–2004 by the National Oceanic and Atmospheric Administration (NOAA) at Buoy Station 46025 – Santa Monica Basin. Mixing heights were set to 500 meters and relative humidity was set to 80%. The original ambient air impacts analysis had been further revised to include potential effects of platform downwash using the same FSRU dimensions that were used for the screening analysis for ammonia impacts. The OCD model was recompiled to allow the use of up to 50,000 receptors per run. No changes to the model or meteorological data have been made since the December 2005 submittal.

[1] Revised emissions estimates were submitted under separate cover.
[2] Onshore, Ventura-Emma Wood State Beach (from Ventura County Air Pollution Control District); offshore, NOAA Buoy Station 46025.

1.2 PROJECT EMISSIONS

Estimates of the Project's emissions were included in the December 2005 Minor New Source Review Construction Permit application. In September 2006, Project emission estimates were revised to reflect responses to comments provided to BHP by reviewers. The changes to the emissions inventory were outlined in our September 21 data gap response. The revised emission rates were used in this air quality impact analysis. Other major changes to the modeling analysis since the previous report are as follows:

- LNG carrier pumping emissions have been allocated to the FSRU for modeling purposes.
- At E&E's request, emissions sources on the FSRU have been disaggregated so that multiple identical units (such as the main generators and the submerged combustion vaporizers) are modeled with individual stacks.
- As discussed in the September 21 data gap response, two different LNG carrier sizes have been addressed.

Table 1-1 below summarizes the revised emissions from the sources located on the FSRU and from vessel operations in District and federal waters.

The activity data on which these emissions calculations are based have been provided to the agencies by the applicant under separate cover. These activity data were the basis for calculation of emissions over shorter periods to allow comparison of modeled impacts with short-term ambient air quality standards. These data were also the basis for allocation of emissions to various source locations for modeling. The emission rates used in the modeling analysis are documented in the appendix.

1.3 AIR QUALITY IMPACT ANALYSIS

1.3.1 Receptor Locations

The overwater receptor grid extended approximately 22 miles up and down the coast from the FSRU. The overland receptor grid extended two miles inland from the shoreline with additional receptors in the Oxnard area. Additional receptors were placed along the shoreline of the South Coast Air Basin from Point Dume to the Palos Verdes peninsula.

Receptors have been excluded from a 500-meter exclusion zone surrounding the FSRU. Under federal law (33 CFR 165.2 Subpart C, Safety Zones), a safety zone is an area "to which for safety or environmental purposes, access is limited to authorized persons, vehicles, or vessels. It may be stationary and described by fixed limits or it may be described as a zone around a vessel in motion." The Applicant has requested from the U.S. Coast Guard a safety zone with a radius of 500 meters from the outer edge of the FSRU. If the project is approved, the safety zone will be added to navigation charts as a limited access area only, established in accordance with 33 CFR Part 150. Only LNG carriers bound for the FSRU and service and supply vessels associated with the FSRU and LNG carrier operations would be allowed to enter the safety zone. By federal law,

Table 1-1
Cabrillo Port Operational Emissions Summary

	Emissions, tons per year				
Description	**NOx**	**ROC**	**CO**	**SO_2**	**$PM_{10}/PM_{2.5}$[a]**
Stationary Source (FSRU)					
Wartsila 9L50DF Main Generators	12.2	24.5	20.8	0.08	8.1
Wartsila 9L50DF Backup Generator	1.9	0.3	0.2	0.01	0.1
Submerged Combustion Vaporizers	48.9	3.5	148.9	0.33	3.8
Emergency Fire Pump and Generator	3.0	0.4	1.9	<0.01	0.1
Freefall Lifeboat	<0.1	<0.1	<0.1	<0.01	<0.1
Diesel Fuel Storage Tank	--	0.03	--	--	--
LNG Carrier Pumping	9.4	2.7	6.6	<0.01	0.4
Total Stationary Source	**75.4**	**31.4**	**178.4**	**0.42**	**12.6**
Marine Vessels, District Waters[b]					
Tug Supply Boats	0.22	0.09	0.21	0.001	0.01
Crew Boat	0.06	0.03	0.06	0.000	0.00
Subtotal, District Waters	**0.28**	**0.12**	**0.27**	**0.002**	**0.02**
Marine Vessels, Federal Waters[c]					
Tug Supply Boats	27.1	11.6	25.9	0.17	1.5
Crew Boat	0.8	0.3	0.8	0.01	<0.01
LNG Carrier	21.1	6.1	14.9	0.01	0.9
Subtotal, Federal Waters	**49.0**	**18.0**	**41.6**	**0.2**	**2.5**

Notes: a. All PM_{10} assumed to be $PM_{2.5}$.
b. District waters extend approximately 3.5 miles from shoreline.
c. Federal waters extend from the District water boundary to approximately 25 miles from shoreline.

the general public would no longer have access to this area. The safety zone would be rigorously patrolled to prevent the incursion of unauthorized personnel.

This exclusion is consistent with the December 19, 1980 letter from Douglas Costle to Senator Jennings Randolph stating that an "exemption from ambient air is available only for the atmosphere over land owned or controlled by the source and to which public access is precluded by a fence or other physical barriers." This exemption was further clarified in an April 30,1987 letter from G.T. Helms of OAQPS to Steve Rothblatt, Chief of the Region V Air Division, stating that receptors must be placed in a river that is a public waterway because it is not controlled by the source. However, the letter also lays out the conditions under which the adjacent riverbank may be excluded from ambient air: '[t]he riverbank must be clearly posted and regularly patrolled by plant security. It must be very clear that the area is not public." Because the safety zone is an area that will be controlled by the source, clearly posted on navigational charts, and rigorously patrolled, the general public will not have access to the area and the safety zone is not considered

to be ambient air. This approach is consistent with the way in which EPA Region 6 handled the safety zone for the El Paso Energy Bridge (now, Gulf Gateway Energy Bridge). In that situation, EPA recognized that the general public is excluded from the safety zone and so the area within the safety zone does not meet the definition of "ambient air."

1.3.2 Results of the Air Quality Impact Analysis

Results of the air quality modeling analysis are summarized in Tables 1-2 and 1-3. Table 1-2 compares the maximum modeled concentrations from project emissions to the PSD significance thresholds and Class II increments. The time, date, and location of the modeled maximum impact for each pollutant and averaging period are shown in Attachment 1.[3] Table 1-2 shows that the maximum project impacts for all pollutants and averaging periods occur at sea. Table 1-2 also shows that with the exception of annual average impacts, maximum modeled impacts of the project in the South Coast Air Basin are less than half of the maximum modeled onshore impacts. With the exception of annual average NO_2, all project impacts are well below all significance thresholds. The area in which the modeled annual average NO_2 concentrations exceed the significant impact level extends less than 2,000 meters to the east of the Coast Guard exclusion zone, immediately adjacent to the FSRU and located over 10 miles from any onshore receptors. Modeled impacts for all pollutants and averaging periods are much lower onshore.

Table 1-3 shows the maximum modeled onshore impacts from the project combined with representative background pollutant concentrations, and compare these total projected impacts with the state and federal ambient air quality standards. Background concentrations in these tables have been updated to reflect the highest values monitored during the period 2000 through 2004. These results show that emissions from the proposed FSRU would not cause or contribute to any violations of any state or federal ambient air quality standard. EPA has stated that it is its longstanding policy to use significant impact levels to determine whether a proposed new or modified source will cause or contribute significantly to a violation of the national ambient air quality standards (NAAQS) or PSD increments. If a source's maximum impacts are below the significant impact levels, then the source is judged to not cause or contribute significantly to a NAAQS or increment violation. As the Project's onshore impacts are well below the significant impact levels for each pollutant, the Project will not cause or contribute to a NAAQS or increment violation.

[3] Because OCD does not have the capability of performing ozone limiting calculations automatically, the maximum one-hour average NOx concentration calculated for each meteorological data year was converted to NO_2 using the maximum hourly ozone concentration monitored at El Rio for the corresponding year. See attached table for ozone values and calculations.

Table 1-2
Comparison of Maximum Modeled Project Impacts with PSD Significance Thresholds and Class II Increments (Stationary Sources and Marine Vessels, Including LNG Carriers)

Pollutant	Avg Period	Max. Modeled Offshore Impact ($\mu g/m^3$)	Max. Modeled Onshore Impact ($\mu g/m^3$)	Max. Modeled Impact in SoCAB ($\mu g/m^3$)	PSD Significance Threshold ($\mu g/m^3$)	PSD Class II Increment ($\mu g/m^3$)
NO_2	1-hour [a]	187.9	43.7	14.3	--	--
	annual	3.6	0.03	0.03	1.0	25
SO_2	1-hour	0.7	0.1	0.04	--	--
	3-hour	0.6	0.05	0.02	25	325
	24-hour	0.1	0.05	0.02	5	91
	annual	0.02	<0.01	<0.01	1.0	20
CO	1-hour	313.9	65.4	19.6	2,000	--
	8-hour	186.0	7.1	2.6	500	--
$PM_{10}/PM_{2.5}$	24-hour	2.0	0.2	0.05	5	30
	annual	0.3	<0.01	<0.01	1.0	17

Note: a. 1-hour average NOx converted to NO_2 using highest 1-hour average ozone concentration during the corresponding calendar year. See attached table.

Table 1-3
Comparison of Maximum Modeled Project Onshore Impacts with Ambient Air Quality Standards (Stationary Sources and Marine Vessels, including LNG Carriers)

Pollutant	Avg Period	Max. Modeled Onshore Impact ($\mu g/m^3$)	Background Conc. ($\mu g/m^3$)[a]	Total Impact ($\mu g/m^3$)	State Standard ($\mu g/m^3$)	Federal Standard ($\mu g/m^3$)
NO_2	1-hour	43.7	139.1	182.8	470	--
	annual	0.03	26	26	--	100
SO_2	1-hour	0.1	39.3	39.4	655	--
	3-hour	0.05	39	39	--	1,300
	24-hour	0.05	23.5	23.5	105	365
	annual	<0.01	10.7	10.7	--	80
CO	1-hour	65.4	8,280	8,345	23,000	40,000
	8-hour	7.1	4,000	4,007	10,000	10,000
PM_{10}	24-hour	0.2	127.2	127.4	50	150
	annual	<0.01	29	29	20	50
$PM_{2.5}$	24-hour	0.2	32[b]	32	--	65
	annual	<0.01	13	13	12	15

Notes: a. Background values from El Rio monitoring station (Station ID No. 061113001).
b. 24-hour average background value for $PM_{2.5}$ based on 98th percentile.

The District consists of both attainment and nonattainment areas. Anacapa Island and San Nicolas Island are within the District boundaries and are designated as attainment for all federal standards. The portion of the County on the mainland is designated as a moderate nonattainment area for ozone and as an attainment area for all other federal standards. The Project is essentially the same distance from Anacapa Island as the mainland. In Figures 1-1 through 1-4 it can be seen that the impacts to Anacapa Island from the combined FSRU source and marine vessel emissions are less than or equal to the impacts on the mainland for all pollutants. Therefore, this report focuses on impacts to the mainland.

Table 1-2 shows that the maximum project impacts for all pollutants and averaging periods occur at sea. Modeled impacts for all pollutants and averaging periods are much lower onshore. Figures 1-1 through 1-4 show the modeled impacts of one-hour and annual NO_2 and 24-hour and annual PM_{10}/$PM_{2.5}$ from the stationary sources on the FSRU and the associated marine vessel activity in the vicinity of the project. Figure 1-5 shows the locations of the receptors used in the modeling analysis upon which Figures 1-1 through 1-4 are based. Figure 1-6 shows the locations of the receptors used to evaluate impacts of the project in the South Coast Air Basin.

Figures 1-7 through 1-10 show the modeled impacts of one-hour and annual NO_2 and 24-hour and annual PM_{10}/$PM_{2.5}$ from the stationary sources on the FSRU and the associated marine vessel activity along the coastline of the South Coast Air Basin and compare these modeled impacts to the California and national ambient air quality standards.

2.0 ASSESSMENT OF SIGNIFICANCE

2.1 SIGNIFICANCE COMPARISON TABLES

In the following tables, the maximum onshore ambient air quality impacts of the Cabrillo Port LNG facility are compared with the relevant federal concentration-based significance criteria for each pollutant.

2.1.1 Nitrogen Dioxide

Table 2.1 compares the onshore NO_2 impacts from the proposed Project with the ambient air quality standards and the Class I and Class II significant impact levels for NO_2. EPA specifies that a major source will not be considered to cause or contribute to a violation of a national ambient air quality standard if the ambient impacts attributable to that major source are less than or equal to the Class II significance levels at any locality that does not or would not meet the applicable national standard. 40 CFR § 51.165(b)(2). Ventura County, in its entirety, is an attainment area for the federal NO_2 standard. Impacts below the significant impact levels demonstrate that the Project will have inconsequential impacts to onshore air quality.

Comparison of the modeling results at the worst-case receptors to the significant impact levels indicates that the Project will not have a material effect upon air quality. None of the onshore impact levels exceed the Class II NO_2 significance level of 1.0 $\mu g/m^3$; maximum predicted impacts are more than an order of magnitude below the significance threshold. Therefore, the facility is not expected to cause or contribute to an onshore violation of the NO_2 ambient air quality standard.

Table 2-1
Assessment of Significance for Onshore Impacts of Oxides of Nitrogen

Measure of Significance	Level	Concentration, $\mu g/m^3$
National AAQS	100 $\mu g/m^3$	0.03
Class II SIL	1.0 $\mu g/m^3$	0.03
Class II increment	25 $\mu g/m^3$	0.03
Class I SIL	0.1 $\mu g/m^3$	0.03
Class I increment	2.5 $\mu g/m^3$	0.03

2.1.2 Ozone

There are no approved air quality models for evaluating the ozone impacts of an individual project. However, the OCD modeling results and the unique attributes of the proposed Project demonstrate that there is insignificant potential for the proposed Project to impact the onshore ozone nonattainment area.

The proposed Project's onshore NO_2 impacts are too small to materially contribute to ozone formation. The proposed Project's annual NO_2 impacts are only 3% of the Class II significant impact level.

Based upon the minimal NO_2 impacts that will be experienced at the shoreline, the proposed Project is not expected to cause or materially contribute to any onshore violation of the ozone standard.

2.1.2 Carbon Monoxide

Table 2-2 compares the CO emission impacts from the proposed project with the ambient air quality standards and the Class II significant impact levels. EPA specifies that a major source will be considered to cause or contribute to a violation of a national ambient air quality standard if the ambient impacts attributable to that major source exceed the Class II significance levels at any locality that does not or would not meet the applicable national standard. 40 CFR § 51.165(b)(2). Ventura County, in its entirety, is an attainment area for the federal CO standards. Impacts below the significant impact levels demonstrate that the Project will have inconsequential impacts to onshore air quality.

A comparison of the modeling results at the worst-case receptors to the significant impact levels indicates that the Project will not have a material effect upon air quality. None of the impact levels exceed the CO significance levels of 500 µg/m^3 (8-hour average) or 2,000 µg/m^3 (1-hour average). Therefore, the facility is not expected to cause or contribute to any onshore violation of the CO ambient air quality standard.

Table 2-2
Assessment of Significance for Onshore Impacts of Carbon Monoxide

Measure of Significance	Level	Concentration, µg/m^3
National AAQS – 1 hr	40,000 µg/m^3	65.4
National AAQS – 8 hr	10,000 µg/m^3	7.1
Class II SIL – 1 hr	2,000 µg/m^3	65.4
Class II SIL – 8 hr	500 µg/m^3	7.1

2.1.3 Sulfur Dioxide

Table 2-3 compares the modeled SO_2 emission impacts from the proposed Project to the ambient air quality standards and the Class I and Class II significant impact levels. EPA specifies that a major source will be considered to cause or contribute to a violation of a national ambient air quality standard if the ambient impacts attributable to that major source exceed the Class II significance levels at any locality that does not or would not meet the applicable national standard. 40 CFR § 51.165(b)(2). Ventura County, in its entirety, is an attainment area for the federal SO_2 standards. Impacts below the significant impact levels demonstrate that the Project will have inconsequential impacts to onshore air quality.

A comparison of the modeling results at the worst-case receptors to the significant impact levels indicates that the Project will not have a material effect upon air quality. None of the impact levels exceed the Class II SO_2 significance levels of 1 µg/m^3 (annual average), 5 µg/m^3 (24-hour average) or 25 µg/m^3 (3-hour average). Therefore, the facility is not expected to cause or contribute to any onshore violation of the SO_2 ambient air quality standard.

Table 2-3
Assessment of Significance for Onshore Impacts of Sulfur Dioxide

Measure of Significance	Level	Concentration, μg/m^3
National AAQS – 3 hr	1300 μg/m^3	0.05
National AAQS – 24 hr	365 μg/m^3	<0.01
National AAQS – annual	80 μg/m^3	<0.01
Class II SIL – 3 hr	25 μg/m^3	0.05
Class II SIL - 24 hr	5 μg/m^3	<0.01
Class II SIL – annual	1.0 μg/m^3	<0.01
Class I SIL - 3 hr	1.0 μg/m^3	0.05
Class I SIL - 24 hr	0.2 μg/m^3	<0.01
Class I SIL – annual	0.1 μg/m^3	<0.01

2.1.4 Fine Particulates

Table 2-4 compares the ambient PM_{10} emission impacts from the proposed Project to the ambient air quality standards and the Class I and Class II significant impact levels. EPA specifies that a major source will be considered to cause or contribute to a violation of a national ambient air quality standard if the ambient impacts attributable to that major source exceed the Class II significance levels at any locality that does not or would not meet the applicable national standard. 40 CFR § 51.165(b)(2). Ventura County, in its entirety, is an attainment area for the federal PM_{10} and $PM_{2.5}$ standards. Impacts below the significant impact levels demonstrate that the Project will have inconsequential impacts on onshore air quality.

A comparison of the modeling results at the worst-case receptors to the significant impact levels indicates that the Project will not have a material effect upon air quality. None of the impact levels exceed the Class II PM_{10} significance levels of 1 μg/m^3 (annual average) or 5 μg/m^3 (24-hour average). While significance levels have yet to be developed for $PM_{2.5}$, the combination of onshore attainment status and the extremely low ambient impacts indicates that the proposed Project will have an insignificant effect upon air quality. Therefore, the facility is not expected to cause or contribute to any onshore violation of the PM_{10} or $PM_{2.5}$ ambient air quality standards.

Table 2-4
Assessment of Significance for Onshore Impacts of Fine Particulates (PM_{10})

Measure of Significance	Level	Concentration, $\mu g/m^3$
National AAQS - 24 hr	150 $\mu g/m^3$	0.2
National AAQS – annual	50 $\mu g/m^3$	<0.01
Class II SIL -24 hr	5 $\mu g/m^3$	0.2
Class II SIL – annual	1 $\mu g/m^3$	<0.01
Class I SIL - 24 hr	0.3 $\mu g/m^3$	0.2
Class I SIL – annual	0.2 $\mu g/m^3$	<0.01

Table 2-5
Assessment of Significance for Onshore Impacts of Fine Particulates ($PM_{2.5}$)

Measure of Significance	Level	Concentration, $\mu g/m^3$
National AAQS - 24 hr	65 $\mu g/m^3$	0.2
National AAQS – annual	15 $\mu g/m^3$	<0.01

2.2 AMBIENT AIR QUALITY IMPACTS

As shown in the modeling results presented in Section 1, the maximum ambient impacts attributable to the proposed Project for all pollutants and averaging periods except annual NO_2 are expected to be less than the significant impact levels at the worst-case receptors. Impacts will be lower still onshore. As a result, the operation of the proposed Project will not cause or contribute to exceedances of the NAAQS for any pollutant. Accordingly, the Cabrillo Port LNG Terminal will not have a material impact on onshore ambient air quality.

2.3 OVERALL ASSESSMENT OF SIGNIFICANCE

The analysis of impacts on air quality offshore within 22 miles of the facility and onshore between Oxnard to the north and the Palos Verdes Peninsula to the south shows that the operation of the Cabrillo Port LNG Terminal will not cause or contribute to violations of the NAAQS. Further, the onshore impacts are not considered to be significant when compared with relevant measures of significance.

Attachments

Documentation for Emissions Calculations
Release Parameters for FSRU Sources
Emission Rates and Stack Parameters for FSRU Sources
Maximum Hourly Emissions for Tug Main Generators
Maximum Hourly Emissions for Tug Auxiliary Generators
Maximum Hourly Emissions for Crew Boat Main Generator
Maximum Hourly Emissions for Crew Boat Auxiliary Generator
Maximum Hourly Emissions from Small LNG Carrier
Maximum Hourly Emissions from Large LNG Carrier
Vessel Emissions and Activity in District Waters
Vessel Emissions and Activity in Federal Waters
Release Parameters for Support Vessels
Stack Parameters for Vessel Activity

Documentation for Emissions Calculations

FSRU Sources

Main Generators

- **hourly emissions from "FSRU Table 5", FSRU operational Version 6 9-15-06.xls**
- **annual emissions from "FSRU Table 2", FSRU operational Version 6 9-15-06.xls**

Vaporizers

- **one-hour and 3-hour averages from FSRU Table 11, FSRU operational Version 6 9-15-06.xls (7.5 units in operation for emissions calculations; modeled as 8 physical units)**
- **eight-hour average emission rates calculated as 6 hours with 7.5 units operating plus two hours with 4 units operating; modeled as 8 physical units**
- **24-hour average from FSRU Table 10, FSRU operational Version 6 9-15-06.xls (4 units in operation for emissions calculations; modeled as 4 physical units)**
- **annual emissions from "Table FSRU 9", FSRU operational Version 6 9-15-06.xls**

Emergency Generator

- **hourly and annual emissions from "FSRU Table 14", FSRU operational Version 6 9-15-06.xls**
- **based on 1 hour/day and 100 hours/yr of operation**

Fire Pump Engine

- **hourly and annual emissions from "FSRU Table 13", FSRU operational Version 6 9-15-06.xls**
- **based on 1 hour/day and 100 hours/yr of operation**

Life Boat

- **hourly and annual emissions from "FSRU Table 15", FSRU operational Version 6 9-15-06.xls**
- **based on 1 hour/day and 50 hours/yr of operation**

Backup Generator

- **annual emissions from "Table FSRU 7", FSRU operational Version 6 9-15-06.xls**

LNG Carrier (pumping)

- **hourly and annual emissions from "Table FSRU 16", FSRU operational Version 6 9-15-06.xls**

Vessels

Assist Tugs, Crew Boat and LNG Carrier

- **Maximum hourly emissions for each engine and vessel type were calculated from Tables FW 2, FW 3, FW 5, FW 6, FW 8 and F9 of Federal Waters version 9-29-06.xls by setting the load factor in cell B9 of each table to 100%. The resulting full load hourly emission rates are shown on the attached copies of the modified tables.**
- **Actual hourly emission rates for each vessel type were calculated using the engine loads shown in the table notes for "Support Vessels in District Waters" and in the table body for "Vessel Emissions and Activity in Federal Waters."**

  For example, full load NOx emissions for tug supply mains are 55.24 lb/hr and for tug supply gens is 0.173 lb/hr. Hourly NOx emissions for assist tugs in FW1, based on 51% load on the main engines and 50% load on the generators, is calculated as:

  (0.51 * 55.24) = (0.50 * 0.173) = 28.26 lb/hr

- **Emission rates for other averaging periods were calculated using the persistence factors in the following table:**

Vessel Activity by Area During the Startup Period

Vessel Type/Area	Assumed Activity
Averaging Period: 1 hour	
Assist Tugs, District Waters	none
Crew Boat, District Waters	½ hour
Assist Tugs, FW1	none
Crew Boat, FW1	½ hour
Assist Tugs, FW2	1 hour
LNG Carrier, FW2	1 hour
Crew Boat, FW2	none
Assist Tugs, FW3	none
LNG Carrier, FW3	none
Averaging Period: 3 hours	
Assist Tugs, District Waters	none
Crew Boat, District Waters	1 hour
Assist Tugs, FW1	none
Crew Boat, FW1	1 hour
Assist Tugs, FW2	3 hours
LNG Carrier, FW2	3 hours
Crew Boat, FW2	1 hour
Assist Tugs, FW3	none
LNG Carrier, FW3	none

Vessel Activity by Area During the Startup Period

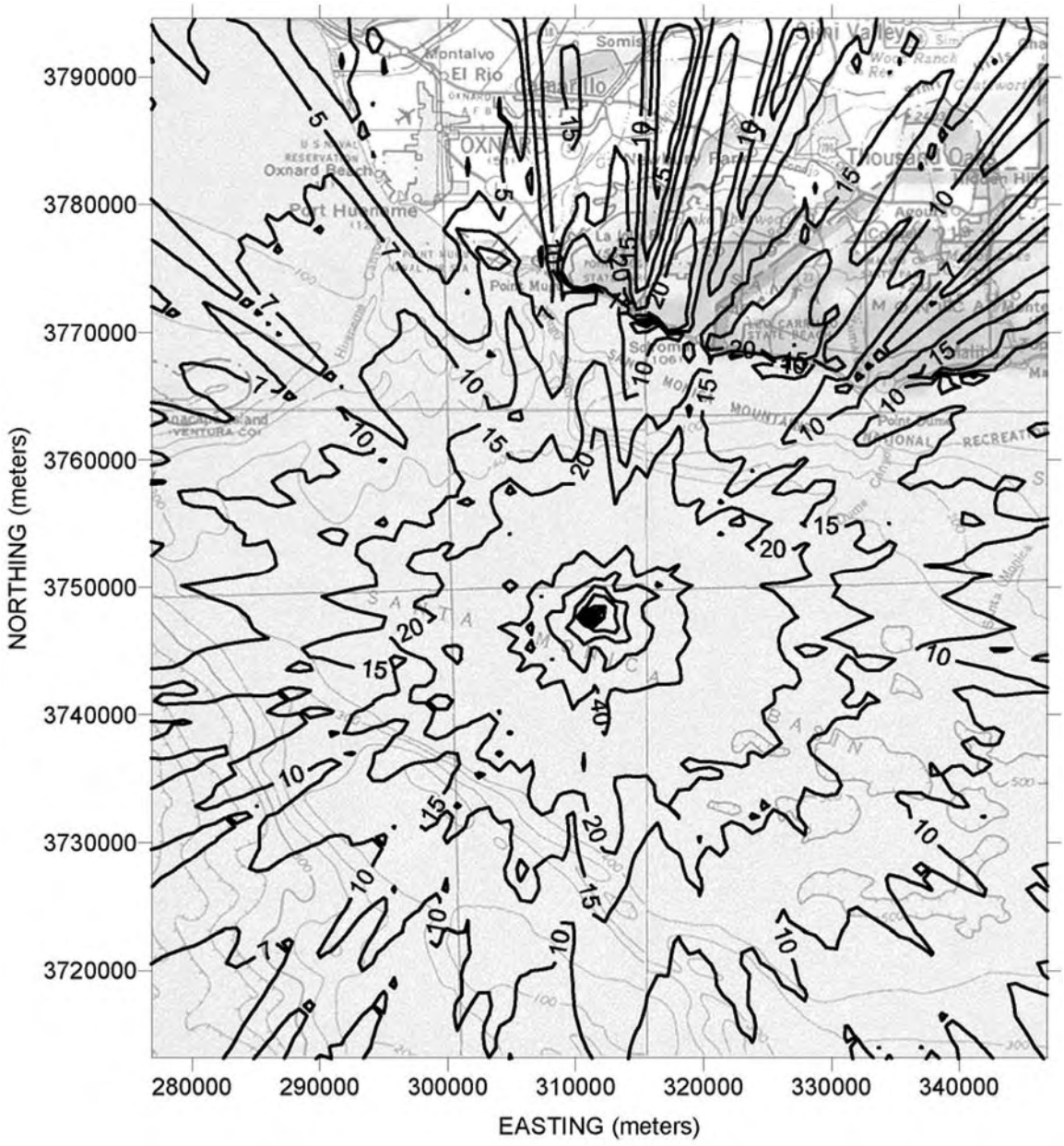
Vessel Type/Area	Assumed Activity
Averaging Period: 8 hours	
Assist Tugs, District Waters	none
Crew Boat, District Waters	1.05 hour
Assist Tugs, FW1	none
Crew Boat, FW1	2 hours
Assist Tugs, FW2	8 hours
LNG Carrier, FW2	8 hours
Crew Boat, FW2	5 hours
Assist Tugs, FW3	none
LNG Carrier, FW3	none
Averaging Period: 24 hours	
Assist Tugs, District Waters	none
Crew Boat, District Waters	1.05 hour
Assist Tugs, FW1	none
Crew Boat, FW1	2 hours
Assist Tugs, FW2	24 hours
LNG Carrier, FW2	24 hours
Crew Boat, FW2	5 hour
Assist Tugs, FW3	none
LNG Carrier, FW3	none
Averaging Period: Annual	
Assist Tugs, District Waters	52 hours
Crew Boat, District Waters	208 hours
Assist Tugs, FW1	104 hours
Crew Boat, FW1	396 hours
Assist Tugs, FW2	8419 hours
LNG Carrier, FW2	1614 hours
Crew Boat, FW2	990 hours
Assist Tugs, FW3	163 hours
LNG Carrier, FW3	455 hours

- **For the LNG carrier, the highest short-term emissions will occur during the larger vessel visits. The highest annual average emissions will occur when smaller carriers are used because more vessel calls (and therefore greater service vessel activity) would be required to deliver the quantity of LNG that can be processed by the FSRU in a year. Carrier impacts will be highest when the vessels are closer to shore, so for short-term averaging periods it was assumed that the carrier was at the FSRU rather than traveling through FW3.**

  Short-term LNG carrier emissions were calculated from the larger carrier emission rates, from Table FW9, Federal Waters version 9-29-06.xls. For example, while within the Safety Zone (FW2), the LNG carrier has an average load factor of 4.42%. Therefore, 1-hour and 8-hour average CO emissions are calculated as 4.42% of the full-load hourly CO emission rate for the large carriers:

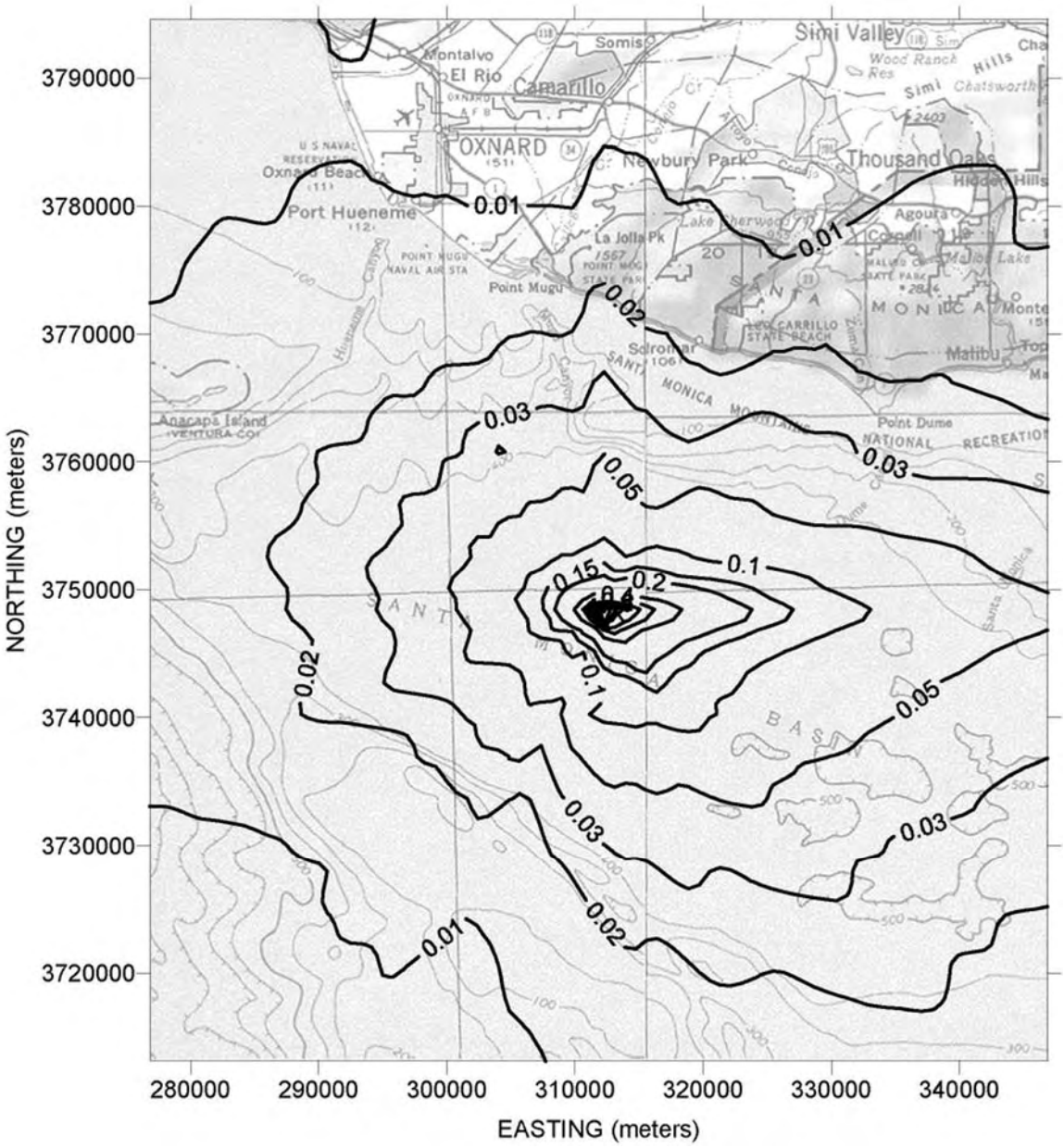
  0.0442 * 137.1 lb/hr = 6.06 lb/hr

Figure 1
BHP Cabrillo LNG Deepwater Port
One-Hour Average NOx Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts



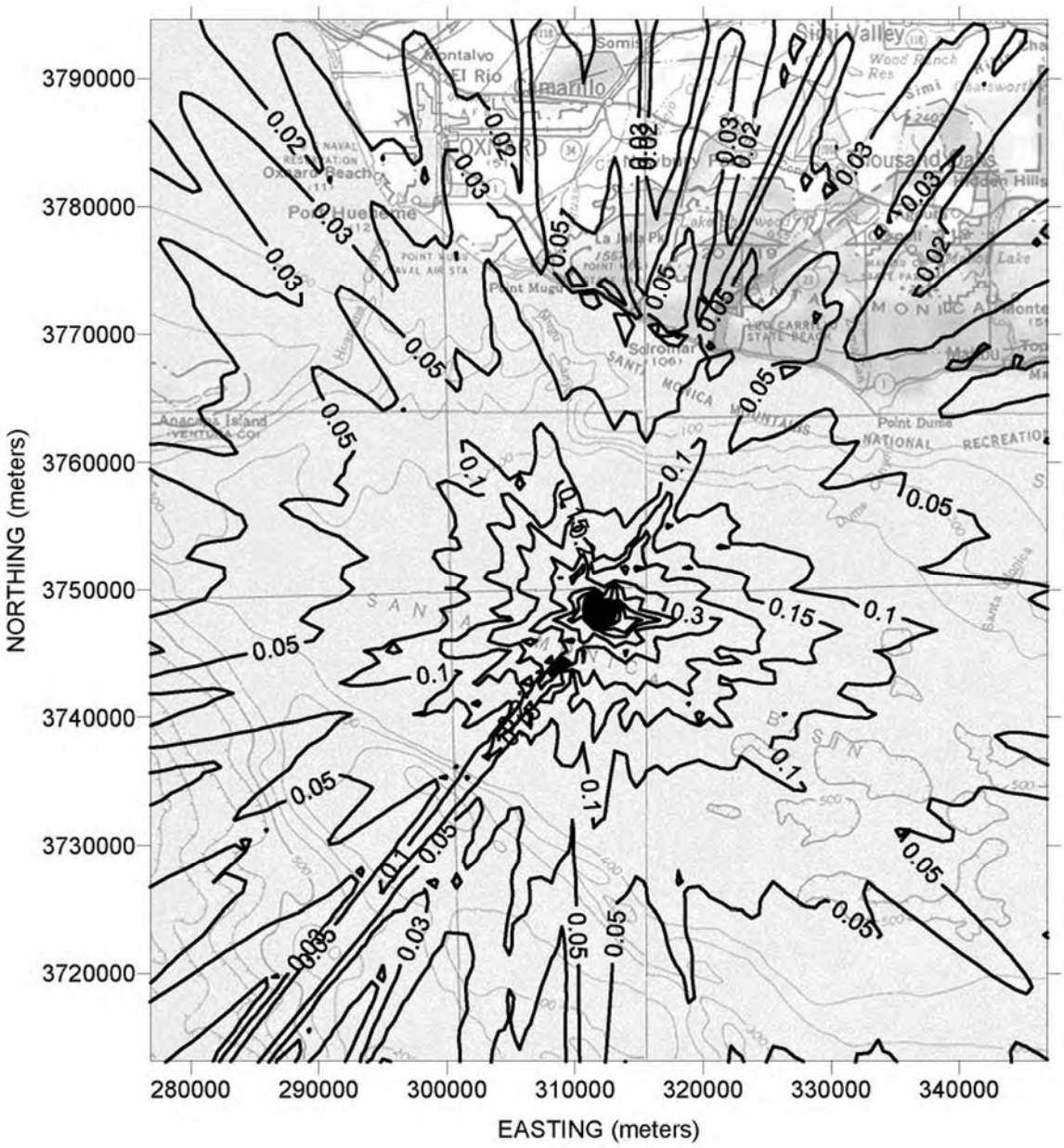
Note: Lines show contours of constant concentration; impacts are in units of $\mu g/m^3$.

Figure 2
BHP Cabrillo LNG Deepwater Port
Annual Average NOx Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts



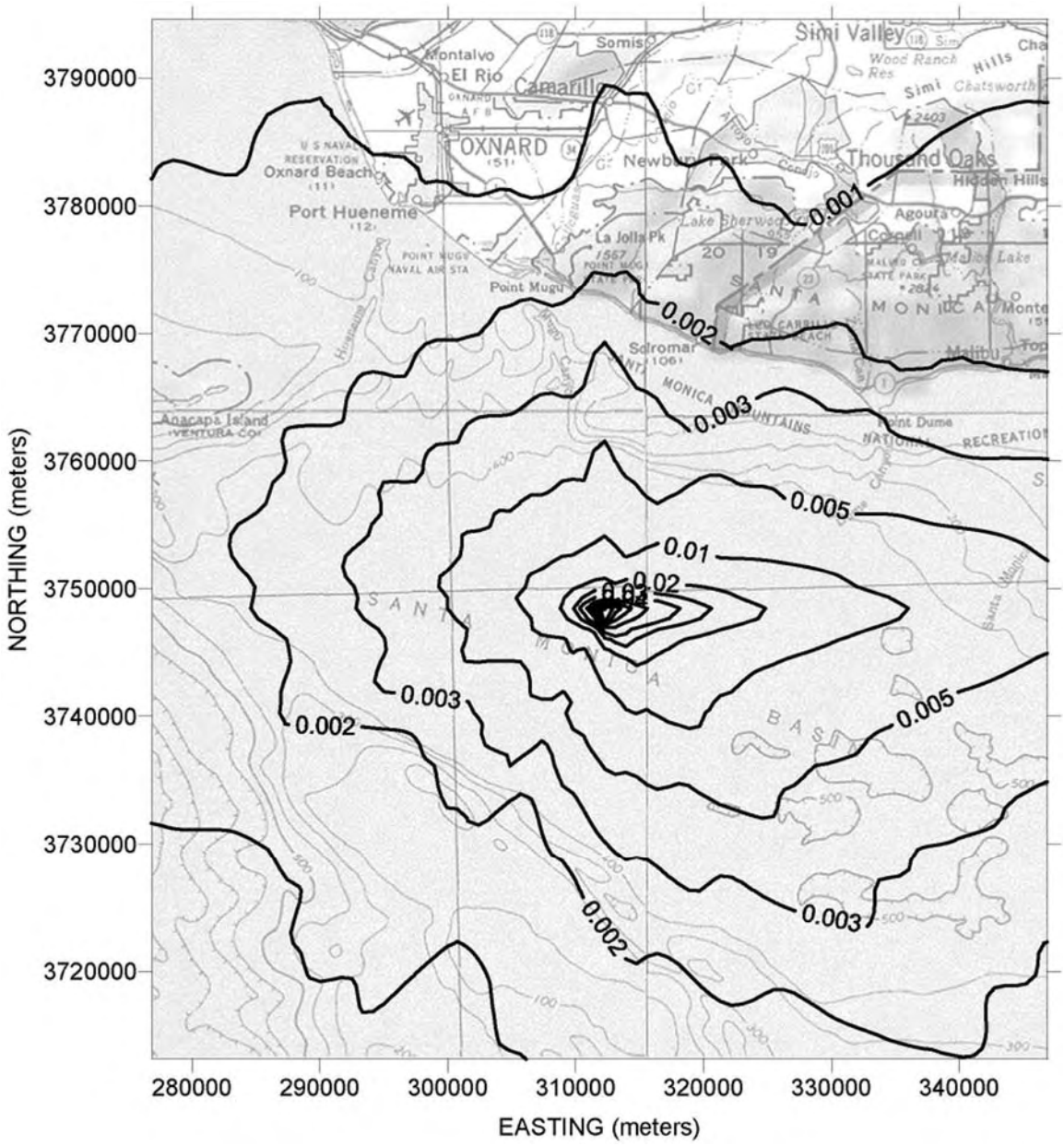
Note: Lines show contours of constant concentration; impacts are in units of $\mu g/m^3$.

Figure 3
BHP Cabrillo LNG Deepwater Port
24-Hour Average PM_{10} Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts



Note: Lines show contours of constant concentration; impacts are in units of $\mu g/m^3$.

Figure 4
BHP Cabrillo LNG Deepwater Port
Annual Average PM_{10} Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts



Note: Lines show contours of constant concentration; impacts are in units of $\mu g/m^3$.

Figure 1-5
Receptors for Air Quality Impact Assessment
BHP Cabrillo LNG Deepwater Port

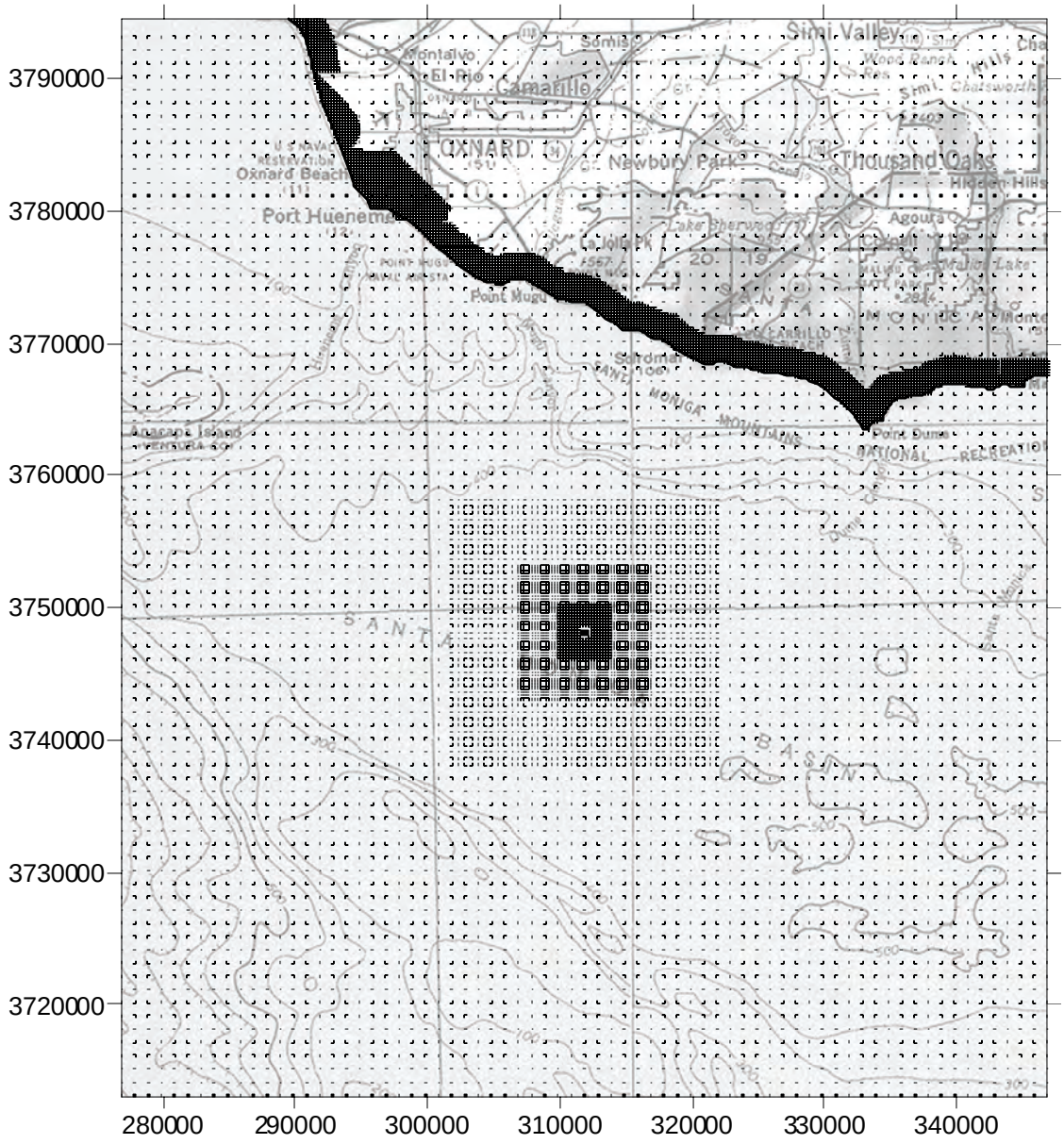


Figure 1-6
BHP Cabrillo LNG Deepwater Port
Locations of Receptors Used to Evaluate Project Impacts in the South Coast Air Basin

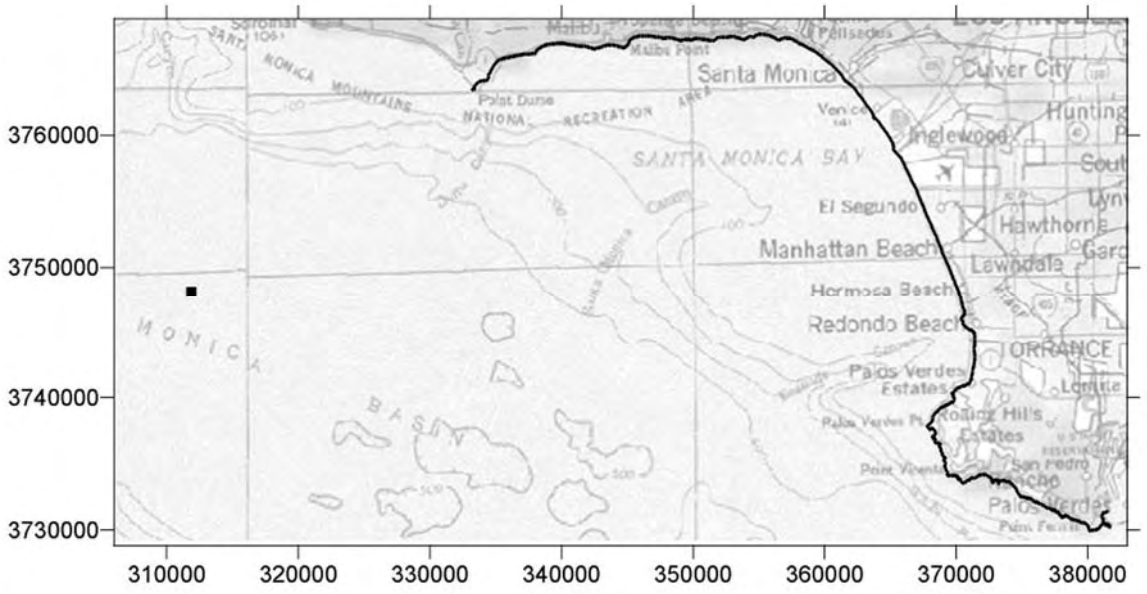


Figure 1-7
BHP Cabrillo LNG Deepwater Port
One-Hour Average NO2 Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts

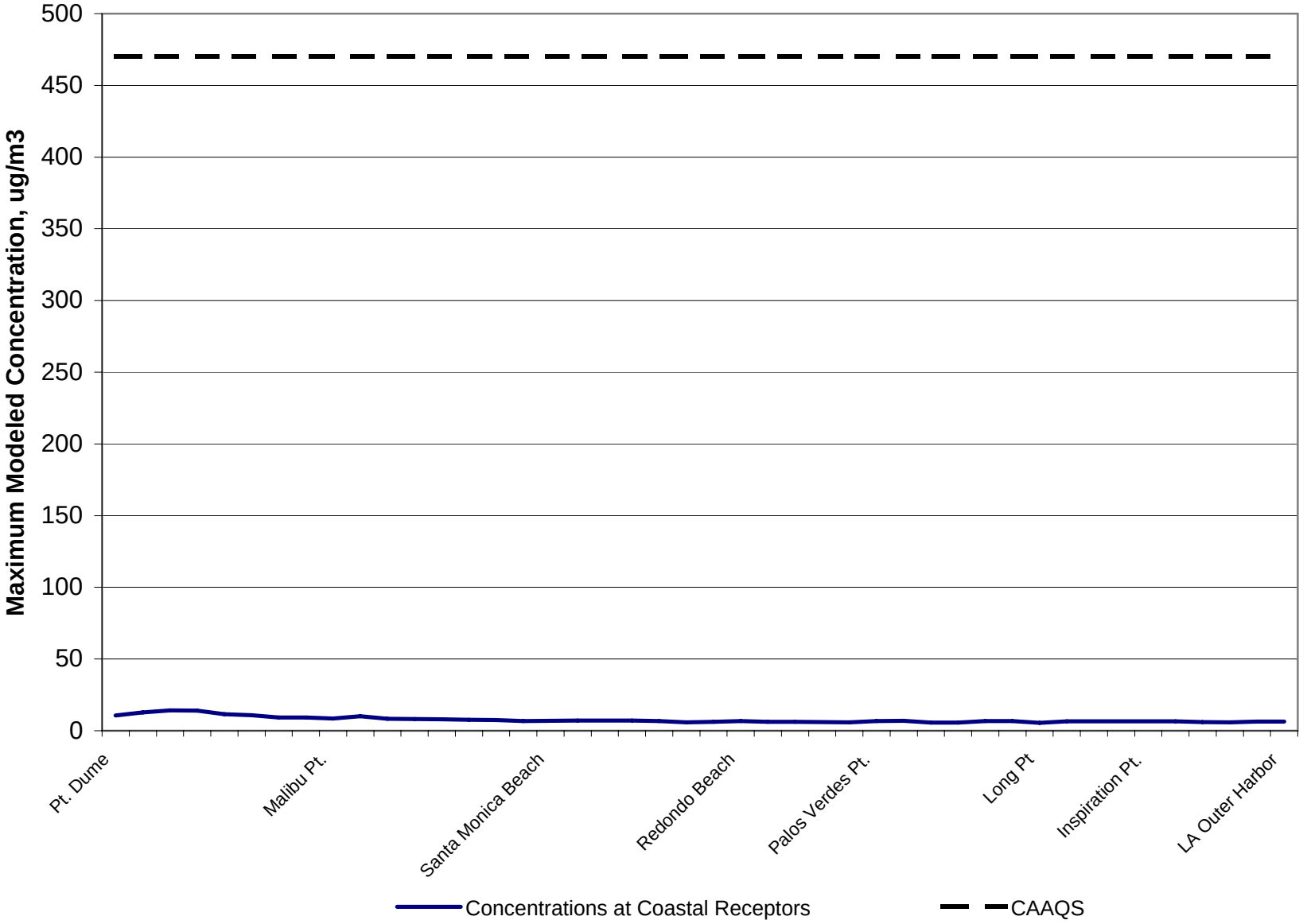


Figure 1-8
BHP Cabrillo LNG Deepwater Port
Annual Average NO2 Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts

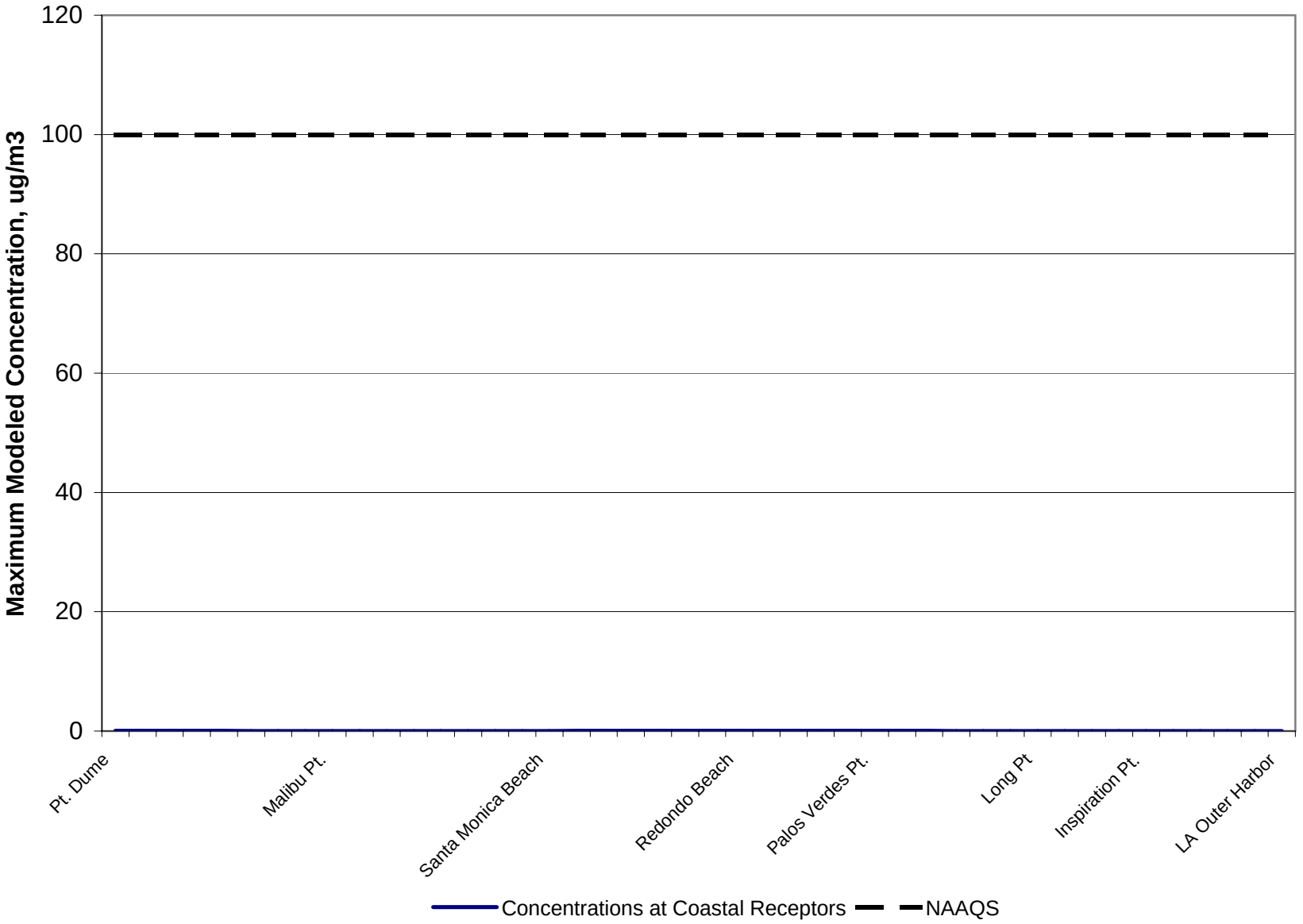


Figure 1-9
BHP Cabrillo LNG Deepwater Port
24-Hour Average PM10/PM2.5 Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts

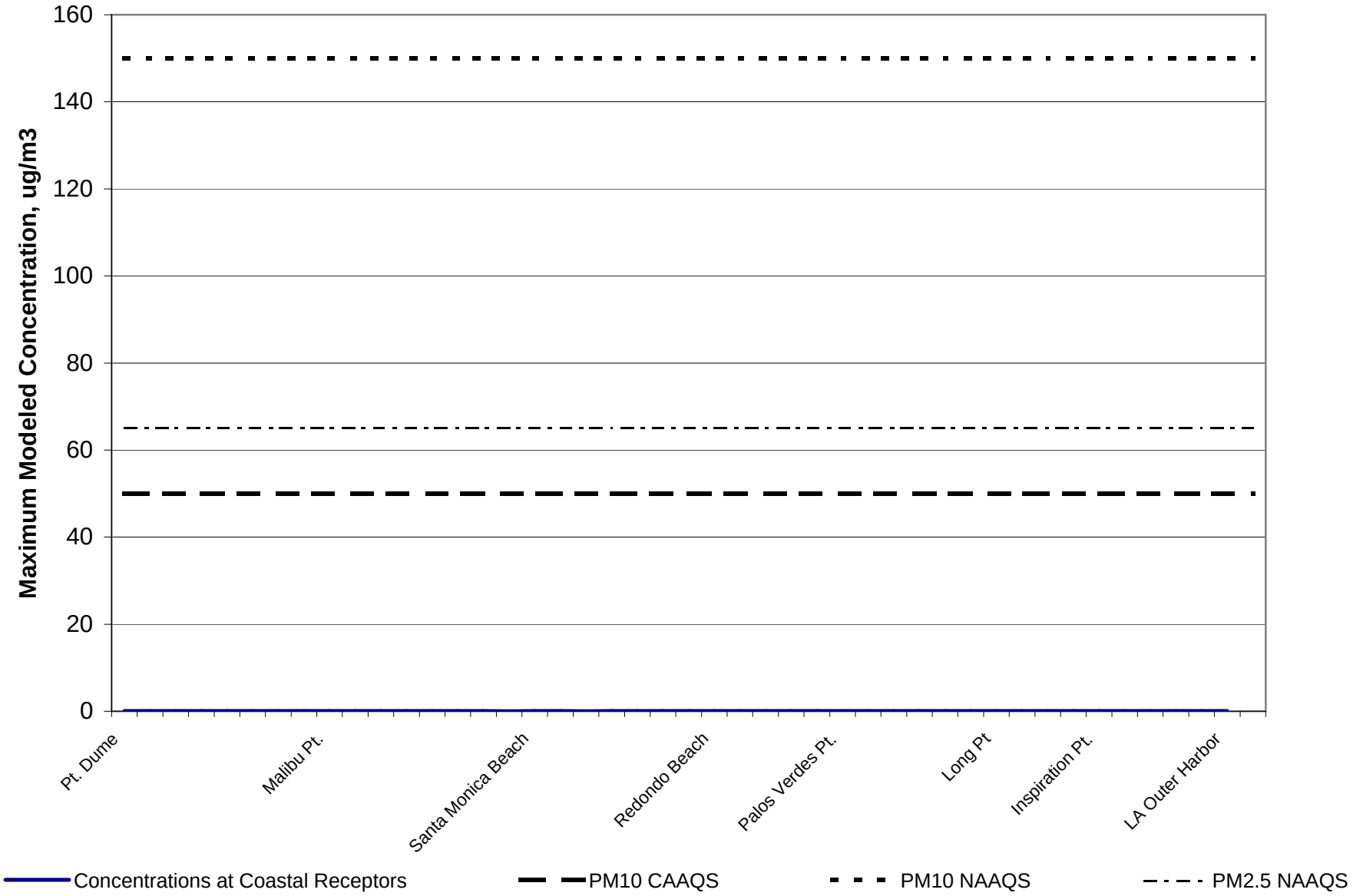
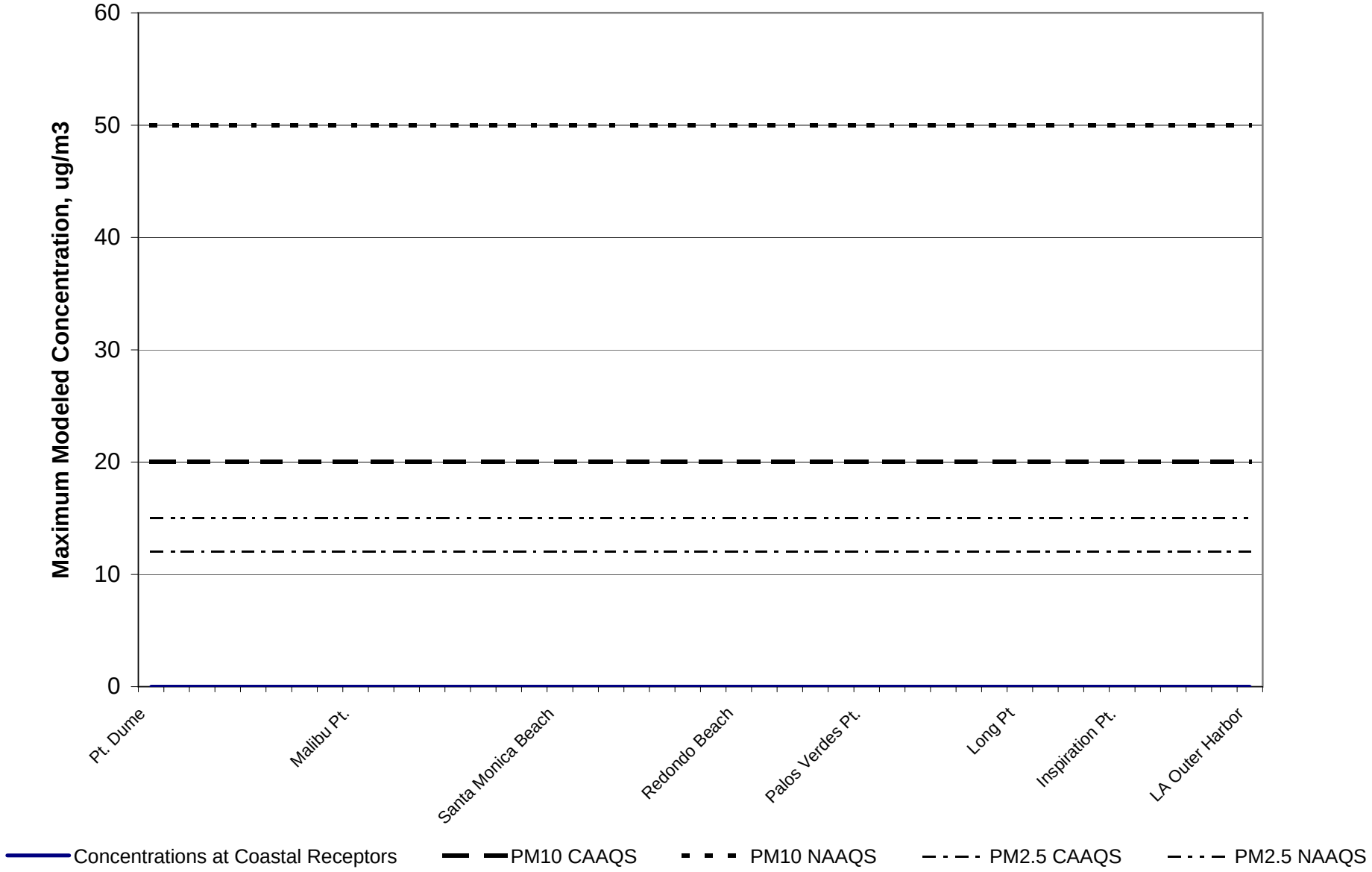


Figure 1-10
BHP Cabrillo LNG Deepwater Port
Annual Average PM10/PM2.5 Impacts: FSRU Sources and Marine Vessels
Maximum Modeled Impacts



Release Parameters for FSRU Sources

Release Parameter	Units	Main Gens	Backup Gen	Vaporizers: Annual	Vaporizers: Max Hour	Vaporizers: Max Daily
Fuel	Type	Dual Fuel	Diesel	Gas	Gas	Gas
Heat Input	mmBTU/hr	65.7	66.3	115.0	107.8	115.0
Wet Fd Factor	wscf/mmBTU	10,608	10,320	10,610	10,610	10,610
Oxygen Content	percent	15%	15%	3%	3%	3%
Exhaust Temperature	Deg F	800	800	70	70	70
Stack Diameter (each)	inches	39.37	39.37	39.37	39.37	39.37
Number of Active Stacks	each	3	1	4	8	6
Stack Area (each)	sq. ft.	8.45	8.45	8.45	8.45	8.45
Stack Flow (each)	wscf/min	41,145	40,424	23,744	22,260	23,744
Stack Flow (each)	wacf/min	98,186	96,467	23,834	22,344	23,834
Stack Velocity (each)	ft/min	11,614	11,411	2,819	2,643	2,819
Release Height	meters	33	33	35	35	35
Release Diameter (each)	meters	1.00	1.00	1.00	1.00	1.00
Release Velocity (each)	meters/sec	59.0	58.0	14.3	13.4	14.3
Release Temperature	degrees K	700	700	294	294	294

Release Parameters for FSRU Sources

Release Parameter	Units	Emerg. Pump	Emerg. Gen	Life Boat	LNG Carrier Pumps	Startup
Fuel	Type	Diesel	Diesel	Diesel	Dual Fuel	Diesel
Heat Input	mmBTU/hr	5.9	35.8	0.64	31.8	49.76
Wet Fd Factor	wscf/mmBTU	10,320	10,320	10,320	10,608	10,320
Oxygen Content	percent	15%	15%	15%	15%	15%
Exhaust Temperature	Deg F	800	800	800	800	800
Stack Diameter (each)	inches	10	26	3	31.50	39.37
Number of Active Stacks	each	1	1	1	1	2
Stack Area (each)	sq. ft.	0.55	3.69	0.05	5.41	8.45
Stack Flow (each)	wscf/min	3,565	21,835	388	19,947	30,318
Stack Flow (each)	wacf/min	8,507	52,106	926	47,600	72,350
Stack Velocity (each)	ft/min	15,597	14,132	18,871	8,798	8,558
Release Height	meters	25	25	1	44	33
Release Diameter (each)	meters	0.25	0.66	0.08	0.80	1.00
Release Velocity (each)	meters/sec	79.2	71.8	95.9	44.7	43.5
Release Temperature	degrees K	700	700	700	700	700

Emission Rates and Stack Parameters for Refined Modeling
BHP Cabrillo LNG Deepwater Port: FSRU Sources

	Stack Diam, m	Stack Height, m	Exh Temp, Deg K	Exhaust Flow, m3/s	Exhaust Velocity, m/s	Emission Rate, g/s NOx	SO2	CO	PM10	Stack Diam, ft	Stack Height, ft	Exh Temp, Deg F	Exh Flow Rate, ft3/m	Exhaust Velocity, ft/s	Emission Rate, lb/hr NOx	SO2	CO	PM10
Averaging Period: 1 hour																		
Main generators (each, 3 units)	1.000	33.000	699.67	46.34	59.000	0.229	1.431E-03	0.390	n/a	3.3	108.3	800	98,186	193.6	1.82	0.01	3.09	n/a
Vaporizers (each, 8 units)	1.000	35.000	294.11	10.545	13.427	0.330	2.239E-03	1.004	n/a	3.28	114.8	70	22,344	44.1	2.62	0.02	7.97	n/a
Emergency generator	0.660	25.000	699.67	24.591	71.792	6.533	7.019E-03	4.083	n/a	2.17	82.0	800	52,106	235.5	51.85	0.06	32.41	n/a
Fire pump	0.254	25.000	699.67	4.015	79.235	0.933	1.146E-03	0.583	n/a	0.83	82.0	800	8,507	260.0	7.41	0.01	4.63	n/a
Life boat	0.076	1.000	699.67	0.437	95.864	0.101	1.248E-04	7.778E-02	n/a	0.3	3.3	800	926	314.5	0.80	0.00	0.62	n/a
LNG Carrier (pumping)	0.800	44.000	699.67	22.465	44.692	2.074	7.258E-04	1.465	n/a	2.6	144.4	800	47,600	146.6	16.46	0.01	11.63	n/a
Averaging Period: 3 hours																		
Main generators (each, 3 units)	1.000	33.000	699.67	46.34	59.000	n/a	1.431E-03	n/a	n/a	3.3	108.3	800	98,186	193.6	n/a	0.01	n/a	n/a
Vaporizers (each, 8 units)	1.000	35.000	294.11	10.545	13.427	n/a	2.239E-03	n/a	n/a	3.28	114.8	70	22,344	44.1	n/a	0.02	n/a	n/a
Emergency generator	0.660	25.000	699.67	24.591	71.792	n/a	2.340E-03	n/a	n/a	2.17	82.0	800	52,106	235.5	n/a	0.02	n/a	n/a
Fire pump	0.254	25.000	699.67	4.015	79.235	n/a	3.820E-04	n/a	n/a	0.83	82.0	800	8,507	260.0	n/a	0.00	n/a	n/a
Life boat	0.076	1.000	699.67	0.437	95.864	n/a	4.159E-05	n/a	n/a	0.25	3.3	800	926	314.5	n/a	0.00	n/a	n/a
LNG Carrier (pumping)	0.800	44.000	699.67	22.465	44.692	n/a	7.258E-04	n/a	n/a	2.62	144.4	800	47,600	146.6	n/a	0.01	n/a	n/a
Averaging Period: 8 hours																		
Main generators (each, 3 units)	1.000	33.000	699.67	46.34	59.000	n/a	n/a	0.390	n/a	3.3	108.3	800	98,186	193.6	n/a	n/a	3.09	n/a
Vaporizers (each, 8 units)	1.000	35.000	294.11	10.545	13.427	n/a	n/a	0.954	n/a	3.28	114.8	70	22,344	44.1	n/a	n/a	7.57	n/a
Emergency generator	0.660	25.000	699.67	24.591	71.792	n/a	n/a	0.510	n/a	2.17	82.0	800	52,106	235.5	n/a	n/a	4.05	n/a
Fire pump	0.254	25.000	699.67	4.015	79.235	n/a	n/a	7.292E-02	n/a	0.83	82.0	800	8,507	260.0	n/a	n/a	0.58	n/a
Life boat	0.076	1.000	699.67	0.437	95.864	n/a	n/a	9.722E-03	n/a	0.25	3.3	800	926	314.5	n/a	n/a	0.08	n/a
LNG Carrier (pumping)	0.800	44.000	699.67	22.465	44.692	n/a	n/a	1.465	n/a	2.62	144.4	800	47,600	146.6	n/a	n/a	11.63	n/a
Averaging Period: 24 hours																		
Main generators (each, 3 units)	1.000	33.000	699.67	46.34	59.000	n/a	1.431E-03	n/a	0.152	3.28	108.3	800	98,186	193.6	n/a	0.01	n/a	1.20
Vaporizers (each, 6 units)	1.000	35.000	294.11	11.248	14.322	n/a	2.389E-03	n/a	2.732E-02	3.28	114.8	70	23,834	47.0	n/a	0.02	n/a	0.22
Emergency generator	0.660	25.000	699.67	24.591	71.792	n/a	2.924E-04	n/a	9.722E-03	2.17	82.0	800	52,106	235.5	n/a	2.32E-03	n/a	0.08
Fire pump	0.254	25.000	699.67	4.015	79.235	n/a	4.775E-05	n/a	1.389E-03	0.83	82.0	800	8,507	260.0	n/a	3.79E-04	n/a	0.01
Life boat	0.076	1.000	699.67	0.437	95.864	n/a	5.199E-06	n/a	2.593E-04	0.25	3.3	800	926	314.5	n/a	4.13E-05	n/a	0.00
LNG Carrier (pumping)	0.800	44.000	699.67	22.465	44.692	n/a	7.258E-04	n/a	9.152E-02	2.62	144.4	800	47,600	146.6	n/a	5.76E-03	n/a	0.73
Averaging Period: Annual																		
Main generators (each, 3 units)	1.000	33.000	699.67	46.34	59.000	0.117	7.318E-04	n/a	7.760E-02	3.28	108.3	800	98,186	193.6	0.93	0.01	n/a	0.62
Backup generator	1.000	33.000	699.67	45.527	57.967	5.563E-02	1.483E-04	n/a	4.029E-03	3.28	108.3	800	96,467	190.2	0.44	0.00	n/a	0.03
Vaporizers (each, 4 units)	1.000	35.000	294.11	11.248	14.322	0.352	2.389E-03	n/a	2.732E-02	3.28	114.8	70	23,834	47.0	2.79	0.02	n/a	0.22
Emergency generator	0.660	25.000	699.67	24.591	71.792	7.458E-02	8.012E-05	n/a	2.664E-03	2.17	82.0	800	52,106	235.5	0.59	6.36E-04	n/a	0.02
Fire pump	0.254	25.000	699.67	4.015	79.235	1.065E-02	1.308E-05	n/a	3.805E-04	0.83	82.0	800	8,507	260.0	0.08	1.04E-04	n/a	3.02E-03
Life boat	0.076	1.000	699.67	0.437	95.864	5.771E-04	7.122E-07	n/a	3.552E-05	0.25	3.3	800	926	314.5	0.0046	5.65E-06	n/a	2.82E-04
LNG Carrier (pumping)	0.800	44.000	699.67	22.465	44.692	2.695E-01	9.433E-05	n/a	1.189E-02	2.62	144.4	800	47,600	146.6	2.1391	7.49E-04	n/a	0.09

Maximum Hourly Emissions from Tug Main Generators

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Main Generator Set Engines, 15,000 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	21242	MW-hrs	
HOURLY PROCESS RATE	11.19	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	
COMBINED ENGINE RATING	15000	BHP	from BHP estimates
LOAD FACTOR	100%	percent	from activity profile
OPERATING SCHEDULE	17264	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	109.08	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	3.55	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			2 vessels based on 100% load MAXIMUM LBS/HR	RATE g/kw-hr	RATE g/bhp-hr	
Nitrogen Oxides (as NO_2)	65	2.4692			55.24	1.120	0.835	
Reactive Hydrocarbons (ROC) as CH_4	80	1.0582			23.67	0.480	0.358	
Carbon Monoxide (CO)	100	2.3149			51.79	1.050	0.783	
Sulfur Dioxide (SO_2)	0.29	0.0152			0.34	0.007	0.005	
Particulates (as PM_{10}) (grains/dscf)	0.0029	0.1323			2.96	0.060	0.045	
Carbon Dioxide (CO_2)	4.44%	1608.9857			35995.21	730	544	

Maximum Hourly Emissions from Tug Auxiliary Generators

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Auxiliary Generator, 150 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	966	MW-hrs	
HOURLY PROCESS RATE	0.11	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	100%	percent	from activity profile
OPERATING SCHEDULE	17264	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	1.09	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.04	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			2 vessels MAXIMUM LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	41	1.5432			0.173	0.700	0.522
Reactive Hydrocarbons (ROC) as CH_4	50	0.6614			0.074	0.300	0.224
Carbon Monoxide (CO)	143	3.3070			0.370	1.500	1.119
Sulfur Dioxide (SO_2)	0.29	0.0152			0.002	0.007	0.005
Particulates (as PM_{10}) (grains/dscf)	0.0044	0.1984			0.022	0.090	0.067
Carbon Dioxide (CO_2)	4.44%	1608.9857			179.976	730	544

Maximum Hourly Emissions from Crew Boat Main Engines

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Main Engines, 1500 BHP		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	1609	MW-hrs	
HOURLY PROCESS RATE	1.12	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	
COMBINED ENGINE RATING	1500	BHP	from BHP estimates
LOAD FACTOR	100%	percent	from activity profile
OPERATING SCHEDULE	1438	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	10.91	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.36	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			100% LOAD MAXIMUM LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	65	2.4692			2.76	1.120	0.835
Reactive Hydrocarbons (ROC) as CH_4	80	1.0582			1.18	0.480	0.358
Carbon Monoxide (CO)	100	2.3149			2.59	1.050	0.783
Sulfur Dioxide (SO_2)	0.29	0.0152			0.02	0.007	0.005
Particulates (as PM_{10}) (grains/dscf)	0.0029	0.1323			0.15	0.060	0.045
Carbon Dioxide (CO_2)	4.44%	1608.9857			1,800	730	544

Maximum Hourly Emissions from Crew Boat Auxiliary Generator

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Generator Engine, 150 BHP		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	161	MW-hrs	
HOURLY PROCESS RATE	0.11	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	100%	percent	from activity profile
OPERATING SCHEDULE	1438	hrs/yr	from activity profile
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	1.09	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.036	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			100% LOAD MAXIMUM LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	41	1.5432			0.17	0.700	0.522
Reactive Hydrocarbons (ROC) as CH_4	50	0.6614			0.07	0.300	0.224
Carbon Monoxide (CO)	143	3.3070			0.37	1.500	1.119
Sulfur Dioxide (SO_2)	0.29	0.0152			0.00	0.007	0.005
Particulates (as PM_{10}) (grains/dscf)	0.0044	0.1984			0.02	0.090	0.067
Carbon Dioxide (CO_2)	4.44%	1608.9857			180	730	544

Maximum Hourly Emissions from Small LNG Carrier

SIC	1321		
PROCESS EQPT DESCRIPTION	LNG Carrier, 33,000 KW Total		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S & 15 ppmw S California diesel pilot charge		
TOTAL YEARLY PROCESS RATE	68277	MW-hrs	
HOURLY PROCESS RATE	33.00	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	33000	KW	from activity profile
LOAD FACTOR	100%	percent	from activity profile
OPERATING SCHEDULE	2069	hrs/yr	from activity profile
HEAT RATE	8533	BTU/KW-hr	
CONVERSION EFFICIENCY	40.0%	percent	
HEAT INPUT	281.57	mmBTU/hr	
DRY Fd	8714	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	8.69	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			ACTUAL LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	140	4.4093			145.51	2.000	1.491
Reactive Hydrocarbons (ROC) as CH_4	116	1.2669			41.81	0.575	0.429
Carbon Monoxide (CO)	163	3.1159			102.82	1.413	1.054
Sulfur Dioxide (SO_2)	0.04	0.0015			0.05	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0052	0.1946			6.42	0.0883	0.066
Carbon Dioxide (CO_2)	4.34%	1305.1434			43,070	592	441

Maximum Hourly Emissions from Large LNG Carrier

SIC	1321		
PROCESS EQPT DESCRIPTION	LNG Carrier, 44,000 KW Total		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S & 15 ppmw S California diesel pilot charge		
TOTAL YEARLY PROCESS RATE	10170	MW-hrs	
HOURLY PROCESS RATE	44.00	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	44000	KW	from activity profile
LOAD FACTOR	100%	percent	from activity profile
OPERATING SCHEDULE	1651	hrs/yr	from activity profile
HEAT RATE	8533	BTU/KW-hr	
CONVERSION EFFICIENCY	40.0%	percent	
HEAT INPUT	52.56	mmBTU/hr	
DRY Fd	8714	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	1.62	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			100% load MAXIMUM LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	1002	4.4093			194.01	2.000	1.491
Reactive Hydrocarbons (ROC) as CH_4	827	1.2669			55.74	0.575	0.429
Carbon Monoxide (CO)	1163	3.1159			137.10	1.413	1.054
Sulfur Dioxide (SO_2)	0.25	0.0015			0.07	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0369	0.1946			8.56	0.0883	0.066
Carbon Dioxide (CO_2)	31.00%	1305.1434			57,426	592	441

Vessel Emissions and Activity in District Waters

Pollutant	Period	Source	
		Tug Supply	Crew Boat
NOx	lb/hr	16.7	1.2
	lb/day	16.7	1.3
	tons/yr	0.22	0.06
SOx	lb/hr	1.0E-01	7.8E-03
	lb/day	1.0E-01	8.2E-03
	tons/yr	1.345E-03	4.056E-04
CO	lb/hr	15.721	1.247
	lb/day	15.721	1.3
	tons/yr	0.21	0.06
PM10	lb/hr	0.9	0.1
	lb/day	0.9	0.1
	tons/yr	1.18E-02	3.73E-03

Vessel Notes:

Tug Supply boats making 52 round trips to FSRU per year, time & load weighted engine operation

Crew boat making 198 round trips to FSRU per year, time & load weighted engine operation

Operating component in state waters only (inside 3-mile limit)

Each vessel makes 1 RT on 1 day.

Each vessel transits District waters in 1/2 hr.

Tug supply vessel travels from FSRU to dock and return: 1 hr in DW in 8-hr prd.

Crew boat travels from dock to FSRU and return: 1 hr in DW in 8-hr prd.

		NOx	SOx	CO	PM10
Vessel Activity between District Water Boundary and FSRU (FW1)					
Assist Tugs (51% engine load on mains; 50% on gens)					
Hours/yr	104				
Emissions, lb/hr		28.26	0.174	26.60	1.520
Emissions, tpy		1.47	0.009	1.38	0.08
Crew Boat (90% engine load on mains; 50% on gens)					
Hours/yr	396				
Emissions, lb/hr		2.57	0.016	2.52	0.144
Emissions, tpy		0.509	0.003	0.498	0.03
Vessel Activity at FSRU (FW2)					
LNG Carrier (4.42% engine load)					
Hours/yr	1614	(small carrier)			
Emissions, lb/hr		8.58	3.00E-03	6.06	0.378
Emissions, tpy		5.2	0.002	3.7	0.2
Assist Tugs (10% engine load on mains; 50% on gens)					
Hours/yr	8419				
Emissions, lb/hr		5.61	0.035	5.36	0.31
Emissions, tpy		23.6	0.1	22.6	1.3
Crew Boat (19% engine load on mains; 50% on gens)					
Hours/yr	990				
Emissions, lb/hr		0.61	0.004069	0.68	0.03921
Emissions, tpy		0.302	0.002	0.34	0.02
Vessel Activity Between FSRU and Federal Waters Boundary (FW3)					
LNG Carrier (48% engine load)					
Hours/yr	455	(small carrier)			
Emissions, lb/hr		93.12	0.03	65.81	4.11
Emissions, tpy		15.9	0.01	11.2	0.7
Assist Tugs (45% engine load on mains; 50% on gens)					
Hours/yr	163				
Emissions, lb/hr		24.94	0.15	23.49	1.34
Emissions, tpy		2.0	0.0	1.9	0.1
Total Emissions in Federal Waters					
Assist Tugs		27.1	0.17	25.9	1.5
Crew Boat		0.8	0.01	0.8	0.0
LNG Carrier		21.1	0.01	14.9	0.9
Total		49.0	0.18	41.6	2.5

Stack Parameters for BHP Cabrillo Support Vessels

Release Parameter	Units	Tug Supply	Crew Boat	Large LNG Carrier	Small LNG Carrier
Fuel	Type	Diesel	Diesel	Dual Fuel	Dual Fuel
Total Engine Rating	BHP	15000	1500	59004	44253
Average Load	percent	30%	47%	14%	14%
Heat Input	mmBTU/hr	32.7	5.1	52.56	39.42
Wet Fd Factor	wscf/mmBTU	10,320	10,320	10,608	10608
Oxygen Content	percent	15%	15%	15%	15%
Exhaust Temperature	Deg F	800	800	800	800
Effective Stack Diameter	inches	30.6	13.0	31.5	31.5
Stack Height	feet	29.5	16.4	144.4	144.4
Stack Area	sq. ft.	5.11	0.92	5.41	5.41
Stack Flow	wscf/min	19,938	3,124	32,919	24,688
Stack Flow	wacf/min	47,579	7,454	78,556	58,916
Stack Velocity	ft/min	9,316	8,087	14,516	10,890
	ft/sec	155	135	241.9	181.5
	mph	105.87	91.89	164.9	123.8
Release Height	meters	9.000	5.000	44	44
Eff Release Diameter	meters	0.78	0.33	0.80	0.80
Release Velocity	meters/sec	47.3	41.1	73.7	55.3
Release Temperature	degrees K	700	700	700	700

Total Engine Rating is total rating of all vessel engines.

Effective stack diameter is equivalent diameter of 4 tug supply stacks.

Heat input is average hourly heat input based on average load on main engine(s) while operating in District waters.

Stack Parameters for Vessel Activity

	Stack Diam, m	Stack Height, m	Exh Temp, Deg K	Exhaust Flow, m3/s	Exhaust Velocity, m/s	Emission Rate, g/s NOx	SO2	CO	PM10
Averaging Period: 1 hour									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	7.678E-02	4.914E-04	7.853E-02	n/a
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	0.162	1.015E-03	0.158	n/a
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	0.707	4.379E-03	0.676	n/a
LNG Carrier FW2	0.800	44.000	699.67	37.07	73.739	1.080	3.782E-04	0.764	n/a
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	n/a	n/a	n/a	n/a
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
LNG Carrier FW3	0.800	44.000	699.67	37.07	73.739	n/a	n/a	n/a	n/a
Averaging Period: 3 hours									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	n/a	3.276E-04	n/a	n/a
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	n/a	6.765E-04	n/a	n/a
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	n/a	4.379E-03	n/a	n/a
LNG Carrier FW2	0.800	44.000	699.67	37.07	73.739	n/a	3.782E-04	n/a	n/a
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	n/a	1.709E-04	n/a	n/a
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
LNG Carrier FW3	0.800	44.000	699.67	37.07	73.739	n/a	n/a	n/a	n/a
Averaging Period: 8 hours									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	n/a	n/a	2.062E-02	n/a
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	n/a	n/a	7.923E-02	n/a
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	n/a	n/a	0.676	n/a
LNG Carrier FW2	0.800	44.000	699.67	37.07	73.739	n/a	n/a	0.764	n/a
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	n/a	n/a	5.331E-02	n/a
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
LNG Carrier FW3	0.800	44.000	699.67	37.07	73.739	n/a	n/a	n/a	n/a
Averaging Period: 24 hours									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	n/a	4.299E-05	n/a	3.956E-04
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	n/a	1.691E-04	n/a	1.515E-03
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	n/a	4.379E-03	n/a	3.868E-02
LNG Carrier FW2	0.800	44.000	699.67	37.07	73.739	n/a	3.782E-04	n/a	4.768E-02
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	n/a	1.068E-04	n/a	1.029E-03
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	n/a	n/a	n/a	n/a
LNG Carrier FW3	0.800	44.000	699.67	37.07	73.739	n/a	n/a	n/a	n/a
Averaging Period: Annual									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	6.262E-03	3.868E-05	n/a	3.403E-04
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	1.823E-03	1.167E-05	n/a	1.073E-04
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	4.227E-02	2.600E-04	n/a	2.274E-03
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	1.465E-02	9.174E-05	n/a	8.217E-04
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	0.679	4.209E-03	n/a	3.718E-02
LNG Carrier FW2	0.800	44.000	699.67	27.81	55.303	0.149	5.226E-05	n/a	6.589E-03
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	8.702E-03	5.794E-05	n/a	5.583E-04
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	5.858E-02	3.604E-04	n/a	3.154E-03
LNG Carrier FW3	0.800	44.000	699.67	27.81	55.303	0.457	1.600E-04	n/a	2.017E-02

LNG Carrier stack height includes hull height, which is 21 meters above water line.
FW1 represents activity between District Water Boundary and FSRU
FW2 represents activity within safety zone and at FSRU
FW3 represents activity between Safety Zone and Federal Waters Boundary

Stack Parameters for Vessel Activity

	Effective Stack Diam, ft	Stack Height, ft	Exh Temp, Deg F	Exh Flow Rate, ft3/m	Exhaust Velocity, ft/s	Emission Rate, lb/hr NOx	SO2	CO	PM10
Averaging Period: 1 ho									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat DW	1.08	16.4	800	7,454	134.8	0.61	3.9E-03	0.62	n/a
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat FW1	1.08	16.4	800	7,454	134.8	1.286	8.1E-03	1.2577	n/a
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	5.61	3.5E-02	5.36	n/a
LNG Carrier FW2	2.63	144.4	800	78,556	241.9	8.58	3.0E-03	6.06	n/a
Crew Boat FW2	1.08	16.4	800	7,454	134.8	n/a	n/a	n/a	n/a
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
LNG Carrier FW3	2.63	144.4	800	78,556	241.9	n/a	n/a	n/a	n/a
Averaging Period: 3 ho									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat DW	1.08	16.4	800	7,454	134.8	n/a	2.6E-03	n/a	n/a
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat FW1	1.08	16.4	800	7,454	134.8	n/a	5.4E-03	n/a	n/a
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	n/a	3.5E-02	n/a	n/a
LNG Carrier FW2	2.63	144.4	800	78,556	241.9	n/a	3.0E-03	n/a	n/a
Crew Boat FW2	1.08	16.4	800	7,454	134.8	n/a	1.4E-03	n/a	n/a
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
LNG Carrier FW3	2.63	144.4	800	78,556	241.9	n/a	n/a	n/a	n/a
Averaging Period: 8 ho									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat DW	1.08	16.4	800	7,454	134.8	n/a	n/a	0.16	n/a
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat FW1	1.08	16.4	800	7,454	134.8	n/a	n/a	0.63	n/a
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	n/a	n/a	5.36	n/a
LNG Carrier FW2	2.63	144.4	800	78,556	241.9	n/a	n/a	6.06	n/a
Crew Boat FW2	1.08	16.4	800	7,454	134.8	n/a	n/a	0.42	n/a
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
LNG Carrier FW3	2.63	144.4	800	78,556	241.9	n/a	n/a	n/a	n/a
Averaging Period: 24 h									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat DW	1.08	16.4	800	7,454	134.8	n/a	3.4E-04	n/a	3.1E-03
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	n/a	n/a	n/a	n/a
Crew Boat FW1	1.08	16.4	800	7,454	134.8	n/a	1.3E-03	n/a	0.01
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	n/a	3.5E-02	n/a	0.31
LNG Carrier FW2	2.63	144.4	800	78,556	241.9	n/a	3.0E-03	n/a	0.38
Crew Boat FW2	1.08	16.4	800	7,454	134.8	n/a	8.5E-04	n/a	0.01
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	n/a	0.0E+00	n/a	0.00
LNG Carrier FW3	2.63	144.4	800	78,556	241.9	n/a	0.0E+00	n/a	0.00
Averaging Period: Ann									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	0.05	3.1E-04	n/a	2.7E-03
Crew Boat DW	1.08	16.4	800	7,454	134.8	0.01	9.3E-05	n/a	8.5E-04
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	0.34	2.1E-03	n/a	0.02
Crew Boat FW1	1.08	16.4	800	7,454	134.8	0.12	7.3E-04	n/a	0.01
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	5.39	3.3E-02	n/a	0.30
LNG Carrier FW2	2.63	144.4	800	58,916	181.5	1.18	4.1E-04	n/a	0.05
Crew Boat FW2	1.08	16.4	800	7,454	134.8	0.07	4.6E-04	n/a	0.00
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	0.46	2.9E-03	n/a	0.03
LNG Carrier FW3	2.63	144.4	800	58,916	181.5	3.63	1.3E-03	n/a	0.16

Time and Location of Maximum Impact by Pollutant and Averaging Period
Project Operation

		Max. Modeled Offshore Impact					Max. Modeled Onshore Impact				
			Time/Date		Location			Time/Date		Location	
Pollutant	Average Period	Conc, ug/m3	Hour	Date	Ux	Uy	Conc, ug/m3	Hour	Date	Ux	Uy
NOx	1-hour (1)	212.9	12	1/6/2003	311570	3747450	43.7	16	11/19/2002	321200	3747750
	annual	3.6	--	2000	312470	3748150	0.03	--	2000	333230	3763600
SO2	1-hour	0.7	18	7/6/2001	311770	3748650	0.1	16	12/27/2000	313400	3772500
	3-hour	0.6	12	9/18/2001	312370	3747950	0.05	18		313400	3772500
	24-hour	0.1	24	3/15//2001	311370	3748400	<0.01	24	12/27/2000	320800	3769000
	annual	0.02	--	2000	312470	3748150	<0.01	--	2000	332600	3764200
CO	1-hour	313.9	19	10/9/2001	312370	3748050	65.4	15	12/27/2000	321100	3769000
	8-hour	186.0	24	2/7/2002	312370	3748350	7.1	16	12/27/2000	313400	3772500
PM10	24-hour	2.0	24	6/2/2003	311470	3748650	0.2	24	1/16/2003	313000	3772800
	annual	0.3	--	2000	312470	3748150	<0.01	--	2001	333230	3763600

Note (1): Max. uncorrected 1-hour average NOx concentration. Maximum ozone-limited 1-hour average NOx concentration of 187.9 ug/m3 on 5/1/2001, hour 19, at 311170, 3747650.

G7-2
Air Quality Impact Assessment of the Startup Operations at the BHP Cabrillo Deepwater Port LNG Import Terminal

sierra research

Air Quality Impact Assessment of Startup Operations at the BHP Cabrillo Deepwater Port LNG Import Terminal

prepared for:

BHP Billiton

October 5, 2006

prepared by:

Sierra Research, Inc.
1801 J Street
Sacramento, California 95814
(916) 444-6666

Revised Assessment of Air Quality Impacts of Startup Activities

The assessment of air quality impacts associated with FSRU startup activities has been revised to reflect the updated assumptions and emission factors provided on September 21.

The OCD model was used with five years of meteorological data to assess the air quality impacts associated with FSRU startup activities. For this analysis, it was assumed that the startup period would last for 60 days (9 weeks for weekly activities) and that normal operation would occur for the remaining 305 days (43 weeks for weekly activities). Short-term emission rates for modeling were calculated based on maximum hourly emission rates for startup activities, as follows:

- Two Wartsila 9L50DF generators operate on Diesel fuel at 75% load, 24 hours per day;
- SCVs do not operate during the startup period;
- Tug/supply boats travel to the FSRU once per week;
- Crew boats make 6 trips per week to the FSRU; and
- LNG carriers do not visit the FSRU during the startup period.

During the startup year it was assumed that there would be 82 small (138 m^3) LNG carrier calls. This was calculated assuming 43 weeks of normal FSRU operation following the startup period.

99 carrier visits/52 weeks * 43 weeks = 81.8 carrier visits (rounded to 82)

As before, vessel activity was allocated to District waters, to the FSRU safety zone, and to Federal waters between the District waters boundary and the FSRU. Activity assumptions are summarized in Table 1.

Table 1
Vessel Activity by Area During the Startup Period

Vessel Type/Area	Assumed Activity
Averaging Period: 1 hour	
Assist Tugs, District Waters	½ hour
Crew Boat, District Waters	½ hour
Assist Tugs, FW1	½ hour
Crew Boat, FW1	½ hour
Averaging Period: 3 hours	
Assist Tugs, District Waters	1 hour
Crew Boat, District Waters	1 hour
Assist Tugs, FW1	1 hour
Crew Boat, FW1	1 hour
Assist Tugs, FW2	1 hour
Crew Boat, FW2	1 hour

Table 1
Vessel Activity by Area During the Startup Period

Vessel Type/Area	Assumed Activity
Averaging Period: 8 hours	
Assist Tugs, District Waters	1 hour
Crew Boat, District Waters	1.05 hour
Assist Tugs, FW1	2 hours
Crew Boat, FW1	2 hours
Assist Tugs, FW2	5 hours
Crew Boat, FW2	5 hours
Averaging Period: 24 hours	
Assist Tugs, District Waters	1 hour
Crew Boat, District Waters	1.05 hour
Assist Tugs, FW1	2 hours
Crew Boat, FW1	2 hours
Assist Tugs, FW2	21 hours
Crew Boat, FW2	5 hours
Averaging Period: Annual	
Assist Tugs, District Waters	52 hours
Crew Boat, District Waters	229 hours
Assist Tugs, FW1	104 hours
Crew Boat, FW1	436 hours
Assist Tugs, FW2	8419 hours
LNG Carrier, FW2	1337 hours
Crew Boat, FW2	1090 hours
Assist Tugs, FW3	163 hours
LNG Carrier, FW3	377 hours

Details regarding emission rates, engine loads, stack parameters and modeling inputs are provided in the attachments. Sample emissions calculations are also provided. Major changes since the previous submittal are as follows:

- As assist tugs and crew boats will be Diesel fueled during normal project operation, the same vessels will be used during startup and normal project operation so there is no difference in emission factors between the two periods. However, it is still assumed that there will be additional crew boat activity during the startup period.

- LNG carrier pumping emissions have been allocated to the FSRU for modeling purposes.

The results of the OCD modeling are summarized and compared with the applicable state and federal ambient air quality standards in Tables 2, 3, and 4.

Table 2
Maximum Modeled Project Impacts During the Startup Period (Stationary Sources and Marine Vessels)

Pollutant	Avg Period	Max. Modeled Offshore Impact ($\mu g/m^3$)	Max. Modeled Onshore Impact ($\mu g/m^3$)	Max. Modeled Impact in SoCAB ($\mu g/m^3$)
NO_2[a]	1-hour	177.6	40.8	11.4
	annual	2.0	<0.1	<0.1
SO_2	1-hour	0.3	0.1	<0.1
	3-hour	0.1	<0.1	<0.1
	24-hour	<0.1	<0.1	<0.1
	annual	<0.1	<0.1	<0.1
CO	1-hour	98.6	17.4	4.9
	8-hour	14.2	1.0	0.3
$PM_{10}/PM_{2.5}$	24-hour	0.8	0.1	<0.1
	annual	0.2	<0.1	<0.1

Note: a. To be conservative, all NOx is assumed to be NO_2 in evaluating ambient impacts.

Table 3
Comparison of Maximum Modeled Project Offshore Impacts During Startup Period with Ambient Air Quality Standards

Pollutant	Avg Period	Max. Modeled Offshore Impact ($\mu g/m^3$)	Background Conc. ($\mu g/m^3$)[a]	Total Impact ($\mu g/m^3$)	State Standard ($\mu g/m^3$)	Federal Standard ($\mu g/m^3$)
NO_2	1-hour	177.6	139.1	316.7	470	--
	annual	2.0	26	28	--	100
SO_2	1-hour	0.3	39.3	39.6	655	--
	3-hour	0.1	39	39	--	1,300
	24-hour	<0.1	23.5	23.5	105	365
	annual	<0.1	10.7	10.7	--	80
CO	1-hour	98.6	8,280	8,379	23,000	40,000
	8-hour	14.2	4,000	4,014	10,000	10,000
PM_{10}	24-hour	0.8	127.2	128	50	150
	annual	0.2	29	29	20	50
$PM_{2.5}$	24-hour	0.8	32[b]	33	--	65
	annual	0.2	13	13	12	15

Note: [a] Background values from El Rio monitoring station (Station ID No. 061113001).
[b] Background values for $PM_{2.5}$ based on 98th percentile.

Table 4
Comparison of Maximum Modeled Project Onshore Impacts During the Startup Period with Ambient Air Quality Standards

Pollutant	Avg Period	Max. Modeled Onshore Impact ($\mu g/m^3$)	Background Conc. ($\mu g/m^3$)[a]	Total Impact ($\mu g/m^3$)	State Standard ($\mu g/m^3$)	Federal Standard ($\mu g/m^3$)
NO_2	1-hour	40.8	139.1	179.9	470	--
	annual	<0.1	26	26	--	100
SO_2	1-hour	0.1	39.3	39.4	655	--
	3-hour	<0.1	39	39	--	1,300
	24-hour	<0.1	23.5	23.5	105	365
	annual	<0.1	10.7	10.7	--	80
CO	1-hour	17.4	8,280	8,297	23,000	40,000
	8-hour	1.0	4,000	4,001	10,000	10,000
PM_{10}	24-hour	0.1	127.2	127.3	50	150
	annual	<0.1	29	29	20	50
$PM_{2.5}$	24-hour	0.1	32[b]	32	--	65
	annual	<0.1	13	13	12	15

Note: [a] Background values from El Rio monitoring station (Station ID No. 061113001).
[b] 24-hour average background value for $PM_{2.5}$ based on 98th percentile.

Attachments

Documentation for Emissions Calculations
Release Parameters for FSRU Sources
Stack Parameters for FSRU Sources During the Startup Year
Maximum Hourly Emission Rates for Tug Supply Mains
Maximum Hourly Emission Rates for Tug Supply Gens
Maximum Hourly Emission Rates for Crew Boat Mains
Maximum Hourly Emission Rates for Crew Boat Gens
Maximum Hourly Emission Rates for LNG Carrier
Support Vessel Emissions in District Waters During the Startup Year
Vessel Emissions and Activity in Federal Waters During the Startup Year
Release Parameters for Support Vessels During the Startup Year
Stack Parameters for Vessel Activity During the Startup Year

Documentation for Emissions Calculations

FSRU Sources

Startup Diesel Generators

- **hourly emissions from "FSRU Startup Table 5", FSRU Startup Emissions 6 12 06.xls**
- **annual emissions from "FSRU Startup Table 2", FSRU Startup Emissions 6 12 06.xls**

Vaporizers

- **do not operate during the startup period, so no short-term emissions modeled**
- **annual emissions from "Table FSRU 9", FSRU operational Version 6 9-15-06.xls, adjusted to reflect 7320 hours of operation during the startup year (305 days times 24 hrs/day)**

Emergency Generator

- **hourly emissions from "FSRU Startup Table 7", FSRU Startup Emissions 6 12 06.xls**
- **annual emissions from "FSRU Startup Table 2", FSRU Startup Emissions 6 12 06.xls**

Fire Pump Engine

- **hourly emissions from "FSRU Startup Table 7", FSRU Startup Emissions 6 12 06.xls**
- **annual emissions from "FSRU Startup Table 2", FSRU Startup Emissions 6 12 06.xls**

Life Boat

- **hourly emissions from "FSRU Startup Table 8", FSRU Startup Emissions 6 12 06.xls**
- **annual emissions from "FSRU Startup Table 2", FSRU Startup Emissions 6 12 06.xls**

Main Generators

- **annual emissions from "Table FSRU 5", FSRU operational Version 6 9-15-06.xls, adjusted to reflect 7320 hours of operation during the startup year (305 days times 24 hrs/day)**

Backup Generator

- **annual emissions from "Table FSRU 7", FSRU operational Version 6 9-15-06.xls, adjusted to reflect 85 hours of operation during the startup year (305 days/365 days * 100 hrs = 83.6, rounded up to 85)**

LNG Carrier (pumping)

- **annual emissions from "Table FSRU 16", FSRU operational Version 6 9-15-06.xls, adjusted to reflect 82 berthings during the startup year (43 weeks/52 weeks * 99 berthings = 81.8, rounded up to 82)**

Vessels

Assist Tugs, Crew Boat and LNG Carrier

- **Maximum hourly emissions for each engine and vessel type were calculated from Tables FW 2, FW 3, FW 5, FW 6 and FW 8 of Federal Waters version 9-29-06.xls by setting the load factor in cell B9 of each table to 100%. The resulting full load hourly emission rates are shown on the attached copies of the modified tables.**
- **Actual hourly emission rates for each vessel type were calculated using the engine loads shown in the table notes for "Support Vessels in District Waters During the Startup Year" and in the table body for "Vessel Emissions and Activity in Federal Waters During the Startup Period."**

  For example, full load NOx emissions for tug supply mains are 55.24 lb/hr and for tug supply gens is 0.173 lb/hr. Hourly NOx emissions for assist tugs in FW1, based on 51% load on the main engines and 50% load on the generators, is calculated as:

  (0.51 * 55.24) = (0.50 * 0.173) = 28.26 lb/hr

- **Emission rates for other averaging periods were calculated using the persistence factors in Table 1 above ("Vessel Activity by Area During the Startup Period").**

Release Parameters for FSRU Sources

Release Parameter	Units	Main Gens	Backup Gen	Vaporizers	Emerg. Pump	Emerg. Gen	Life Boat	Startup	LNG Carrier Pumps
Fuel	Type	Dual Fuel	Diesel	Gas	Diesel	Diesel	Diesel	Diesel	Dual Fuel
Heat Input	mmBTU/hr	197.1	66.3	460.0	5.9	35.8	0.64	99.52	31.8
Wet Fd Factor	wscf/mmBTU	10,608	10,320	10,610	10,320	10,320	10,320	10,320	10,608
Oxygen Content	percent	15%	15%	3%	15%	15%	15%	15%	15%
Exhaust Temperature	Deg F	800	800	70	800	800	800	800	800
Stack Diameter (each)	inches	39.37	39.37	39.37	10.0	26.0	3.0	39.37	31.50
Number of Active Stacks	each	3	1	4	1	1	1	2	1
Stack Diameter (combined)	inches	68.2	39.4	78.7	10.0	26.0	3.0	55.7	31.5
Stack Area	sq. ft.	25.36	8.45	33.82	0.55	3.69	0.05	16.91	5.41
Stack Flow	wscf/min	123,434	40,424	94,976	3,565	21,835	388	60,636	19,947
Stack Flow	wacf/min	294,558	96,467	95,336	8,507	52,106	926	144,700	47,600
Stack Velocity	ft/min	11,614	11,411	2,819	15,597	14,132	18,871	8,558	8,798
Release Height	meters	33	33	35	25	25	1	33	44
Release Diameter (h)	meters	1.73	1.00	2.00	0.25	0.66	0.08	1.41	0.80
Release Velocity	meters/sec	59.0	58.0	14.3	79.2	71.8	95.9	43.5	44.7
Release Temperature (T)	degrees K	700	700	294	700	700	700	700	700
Release Flowrate (V)	wacm/sec	139.01	45.53	44.99	4.01	24.59	0.44	68.29	22.46

Downwash Dimensions	Units	FSRU Hull
Height	meters	21
Width (min horizontal)	meters	65
Length (max horizontal)	meters	286

Emission Rates and Stack Parameters for Refined Modeling
BHP Cabrillo LNG Deepwater Port: FSRU Sources During Startup Period

	Stack Diam, m	Stack Height, m	Exh Temp, Deg K	Exhaust Flow, m3/s	Exhaust Velocity, m/s	Emission Rate, g/s NOx	SO2	CO	PM10	Stack Diam, ft	Stack Height, ft	Exh Temp, Deg F	Exh Flow Rate, ft3/m	Exhaust Velocity, ft/s	Emission Rate, lb/hr NOx	SO2	CO	PM10
Averaging Period: 1 hour																		
Startup Diesel generators (total)	1.414	33.000	699.67	68.29	43.475	7.310	1.949E-02	0.742	n/a	4.6	108.3	800	144,700	142.6	58.02	0.15	5.89	n/a
Vaporizers (total)	2.000	35.000	294.11	44.994	14.322	0	0	0	n/a	6.56	114.8	70	95,336	47.0	0.00	0.00	0.00	n/a
Emergency generator	0.660	25.000	699.67	24.591	71.792	6.533	7.019E-03	4.083	n/a	2.17	82.0	800	52,106	235.5	51.85	0.06	32.41	n/a
Fire pump	0.254	25.000	699.67	4.015	79.235	0.933	1.146E-03	0.583	n/a	0.83	82.0	800	8,507	260.0	7.41	0.01	4.63	n/a
Life boat	0.076	1.000	699.67	0.437	95.864	0.101	1.248E-04	7.778E-02	n/a	0.25	3.3	800	926	314.5	0.80	0.00	0.62	n/a
Averaging Period: 3 hours																		
Startup Diesel generators (total)	1.414	33.000	699.67	68.29	43.475	n/a	1.949E-02	n/a	n/a	4.6	108.3	800	144,700	142.6	n/a	0.15	n/a	n/a
Vaporizers (total)	2.000	35.000	294.11	44.994	14.322	n/a	0	n/a	n/a	6.56	114.8	70	95,336	47.0	n/a	0.00	n/a	n/a
Emergency generator	0.660	25.000	699.67	24.591	71.792	n/a	2.340E-03	n/a	n/a	2.17	82.0	800	52,106	235.5	n/a	0.02	n/a	n/a
Fire pump	0.254	25.000	699.67	4.015	79.235	n/a	3.820E-04	n/a	n/a	0.83	82.0	800	8,507	260.0	n/a	0.00	n/a	n/a
Life boat	0.076	1.000	699.67	0.437	95.864	n/a	4.159E-05	n/a	n/a	0.25	3.3	800	926	314.5	n/a	0.00	n/a	n/a
Averaging Period: 8 hours																		
Startup Diesel generators (total)	1.414	33.000	699.67	68.29	43.475	7.310	n/a	0.742	n/a	4.64	108.3	800	144,700	142.6	58.02	n/a	5.89	n/a
Vaporizers (total)	2.000	35.000	294.11	44.994	14.322	0	n/a	0	n/a	6.56	114.8	70	95,336	47.0	0.00	n/a	0.00	n/a
Emergency generator	0.660	25.000	699.67	24.591	71.792	0.817	n/a	0.510	n/a	2.17	82.0	800	52,106	235.5	6.48	n/a	4.05	n/a
Fire pump	0.254	25.000	699.67	4.015	79.235	0.117	n/a	7.292E-02	n/a	0.83	82.0	800	8,507	260.0	0.93	n/a	0.58	n/a
Life boat	0.076	1.000	699.67	0.437	95.864	1.264E-02	n/a	9.722E-03	n/a	0.25	3.3	800	926	314.5	0.10	n/a	0.08	n/a
Averaging Period: 24 hours																		
Startup Diesel generators (total)	1.414	33.000	699.67	68.29	43.475	n/a	1.949E-02	n/a	0.535	4.64	108.3	800	144,700	142.6	n/a	0.15	n/a	4.25
Vaporizers (total)	2.000	35.000	294.11	44.994	14.322	n/a	0	n/a	0	6.56	114.8	70	95,336	47.0	n/a	0.00	n/a	0.00
Emergency generator	0.660	25.000	699.67	24.591	71.792	n/a	2.924E-04	n/a	9.722E-03	2.17	82.0	800	52,106	235.5	n/a	2.32E-03	n/a	0.08
Fire pump	0.254	25.000	699.67	4.015	79.235	n/a	4.775E-05	n/a	1.389E-03	0.83	82.0	800	8,507	260.0	n/a	3.79E-04	n/a	0.01
Life boat	0.076	1.000	699.67	0.437	95.864	n/a	5.199E-06	n/a	2.593E-04	0.25	3.3	800	926	314.5	n/a	4.13E-05	n/a	0.00
Averaging Period: Annual																		
Main generators (total)	1.732	33.000	699.67	139.02	59.000	0.295	1.843E-03	n/a	0.195	5.68	108.3	800	294,558	193.6	2.34	0.01	n/a	1.55
Startup Diesel generators (total)	1.414	33.000	699.67	68.29	43.475	1.202	3.204E-03	n/a	0.088	4.64	108.3	800	144,700	142.6	9.54	0.03	n/a	0.70
Backup generator	1.000	33.000	699.67	45.53	57.967	0.047	1.261E-04	n/a	3.424E-03	3.28	108.3	800	96,467	190.2	0.38	0.00	n/a	0.03
Vaporizers (total)	2.000	35.000	294.11	44.994	14.322	1.176	7.984E-03	n/a	9.133E-02	6.56	114.8	70	95,336	47.0	9.33	0.06	n/a	0.72
Emergency generator	0.660	25.000	699.67	24.591	71.792	7.458E-02	8.012E-05	n/a	2.664E-03	2.17	82.0	800	52,106	235.5	0.59	6.36E-04	n/a	0.02
Fire pump	0.254	25.000	699.67	4.015	79.235	1.065E-02	1.308E-05	n/a	3.805E-04	0.83	82.0	800	8,507	260.0	0.08	1.04E-04	n/a	3.0E-03
Life boat	0.076	1.000	699.67	0.437	95.864	5.771E-04	7.122E-07	n/a	3.552E-05	0.25	3.3	800	926	314.5	0.00	5.65E-06	n/a	2.8E-04
LNG Carrier (pumping)	0.800	44.00	699.67	22.465	44.692	2.232E-01	7.813E-05	n/a	9.852E-03	2.62	144.36	800	47,600	146.6	1.77	6.20E-04	n/a	0.08

Maximum Hourly Emission Rates for Tug Supply Mains

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Main Generator Set Engines, 15,000 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	21242	MW-hrs	
HOURLY PROCESS RATE	11.19	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	
COMBINED ENGINE RATING	15000	BHP	from BHP estimates
LOAD FACTOR	100%	percent	
OPERATING SCHEDULE	8738	hrs/yr	per vessel during startup year
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	109.08	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	3.55	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			2 vessels based on 100% load MAXIMUM LBS/HR	RATE g/kw-hr	RATE g/bhp-hr	
Nitrogen Oxides (as NO_2)	65	2.4692			55.24	1.120	0.835	
Reactive Hydrocarbons (ROC) as CH_4	80	1.0582			23.67	0.480	0.358	
Carbon Monoxide (CO)	100	2.3149			51.79	1.050	0.783	
Sulfur Dioxide (SO_2)	0.29	0.0152			0.34	0.007	0.005	
Particulates (as PM_{10}) (grains/dscf)	0.0029	0.1323			2.96	0.060	0.045	
Carbon Dioxide (CO_2)	4.44%	1608.9857			35995.21	730	544	

Maximum Hourly Emission Rates for Tug Supply Gens

SIC	1321		
PROCESS EQPT DESCRIPTION	Tug Supply Auxiliary Generator, 150 BHP, 2 vessels alternating port calls		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	966	MW-hrs	
HOURLY PROCESS RATE	0.11	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	100%	percent	
OPERATING SCHEDULE	8738	hrs/yr	per vessel during startup year
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	1.09	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.04	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			2 vessels MAXIMUM LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	41	1.5432			0.173	0.700	0.522
Reactive Hydrocarbons (ROC) as CH_4	50	0.6614			0.074	0.300	0.224
Carbon Monoxide (CO)	143	3.3070			0.370	1.500	1.119
Sulfur Dioxide (SO_2)	0.29	0.0152			0.002	0.007	0.005
Particulates (as PM_{10}) (grains/dscf)	0.0044	0.1984			0.022	0.090	0.067
Carbon Dioxide (CO_2)	4.44%	1608.9857			179.976	730	544

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Maximum Hourly Emissions for Crew Boat Mains

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Main Engines, 1500 BHP		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	1963	MW-hrs	
HOURLY PROCESS RATE	1.12	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	1500	BHP	from BHP estimates
LOAD FACTOR	100%	percent	
OPERATING SCHEDULE	1755	hrs/yr	during startup year
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	10.91	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.36	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			100% LOAD MAXIMUM LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	65	2.4692			2.76	1.120	0.835
Reactive Hydrocarbons (ROC) as CH_4	80	1.0582			1.18	0.480	0.358
Carbon Monoxide (CO)	100	2.3149			2.59	1.050	0.783
Sulfur Dioxide (SO_2)	0.29	0.0152			0.02	0.007	0.005
Particulates (as PM_{10}) (grains/dscf)	0.0029	0.1323			0.15	0.060	0.045
Carbon Dioxide (CO_2)	4.44%	1608.9857			1,800	730	544

Maximum Hourly Emission Rates for Crew Boat Gens

SIC	1321		
PROCESS EQPT DESCRIPTION	Crew Boat Generator Engine, 150 BHP		
FUEL TYPE/PROCESS INFO	CA Diesel, 15 ppm S		
TOTAL YEARLY PROCESS RATE	196	MW-hrs	
HOURLY PROCESS RATE	0.11	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	150	BHP	from BHP estimates
LOAD FACTOR	100%	percent	
OPERATING SCHEDULE	1755	hrs/yr	during startup year
HEAT RATE	9751	BTU/KW-hr	
CONVERSION EFFICIENCY	35.0%	percent	
HEAT INPUT	1.09	mmBTU/hr	
DRY Fd	9190	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	0.036	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			100% LOAD MAXIMUM LBS/HR	RATE* g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	41	1.5432			0.17	0.700	0.522
Reactive Hydrocarbons (ROC) as CH_4	50	0.6614			0.07	0.300	0.224
Carbon Monoxide (CO)	143	3.3070			0.37	1.500	1.119
Sulfur Dioxide (SO_2)	0.29	0.0152			0.00	0.007	0.005
Particulates (as PM_{10}) (grains/dscf)	0.0044	0.1984			0.02	0.090	0.067
Carbon Dioxide (CO_2)	4.44%	1608.9857			180	730	544

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Maximum Hourly Emission Rates for LNG Carrier

SIC	1321		
PROCESS EQPT DESCRIPTION	LNG Carrier, 44,000 KW Total		
FUEL TYPE/PROCESS INFO	Scarborough LNG, 99.7% methane, 1 ppmv S & 15 ppmw S California diesel pilot charge		
TOTAL YEARLY PROCESS RATE	56562	MW-hrs	
HOURLY PROCESS RATE	33.00	MW	
PROCESS UNITS	PT071	MW-hrs	
HIGHER HEATING VALUE	1007.6	BTU/cu ft	Scarborough LNG
COMBINED ENGINE RATING	33000	KW	from activity profile
LOAD FACTOR	100%	percent	
OPERATING SCHEDULE	1714	hrs/yr	based on 82 berthings during startup year
HEAT RATE	8533	BTU/KW-hr	
CONVERSION EFFICIENCY	40.0%	percent	
HEAT INPUT	281.57	mmBTU/hr	
DRY Fd	8714	dscf/mmBTU	USEPA Method 19
EXHAUST FLOW	8.69	mmdscf/hr	

EMITTENT NAME	EMITTENT PPMV	CTL EF LBS/UNIT			100% LOAD MAXIMUM LBS/HR	RATE g/kw-hr	RATE g/bhp-hr
Nitrogen Oxides (as NO_2)	140	4.4093			145.51	2.000	1.491
Reactive Hydrocarbons (ROC) as CH_4	116	1.2669			41.81	0.575	0.429
Carbon Monoxide (CO)	163	3.1159			102.82	1.413	1.054
Sulfur Dioxide (SO_2)	0.04	0.0015			0.05	0.0007	0.0005
Particulates (as PM_{10}) (grains/dscf)	0.0052	0.1946			6.42	0.0883	0.066
Carbon Dioxide (CO_2)	4.34%	1305.1434			43,070	592	441

Support Vessel Emissions in District Waters
During the Startup Year

Pollutant	Period	Source	
		Tug Supply	Crew Boat
NOx	lb/hr	16.7	1.2
	lb/day	16.7	1.3
	tons/yr	0.22	0.14
SOx	lb/hr	1.03E-01	7.8E-03
	lb/day	1.0E-01	8.2E-03
	tons/yr	1.345E-03	8.93E-04
CO	lb/hr	15.721	1.247
	lb/day	15.721	1.309
	tons/yr	0.21	0.14
PM10	lb/hr	0.9	7.2E-02
	lb/day	0.9	7.5E-02
	tons/yr	1.18E-02	8.21E-03

Tug Supply:	1.0	hr/day
	52	trips/yr
	52	hrs/yr
Crew Boat:	1.05	hrs/day
	218	trips/yr
	229	hrs/yr

Vessel Notes:

Tug Supply boats making 52 1-hr round trips to FSRU per year, time & load weighted engine operation (normal schedule)

Crew boat making 218 1.05-hr round trips to FSRU per year, time & load weighted engine operation (6 rt/wk x 9 wksduring startup period and 2 x 82 carrier visits for remainder of year)

Operating component in state waters only (inside 3-mile limit)

Each vessel makes 1 RT on 1 day.

Each vessel transits District waters in 1/2 hr.

Tug supply vessel travels from FSRU to dock and return: 1 hr in DW in 8-hr prd.

Crew boat travels from dock to FSRU and return: 1.05 hr in DW in 8-hr prd.

Vessel Emissions and Activity in Federal Waters
During the Startup Year

		NOx	SOx	CO	PM10
Vessel Activity between District Water Boundary and FSRU (FW1)					
Assist Tugs (51% engine load on mains; 50% on gens)					
Hours/yr	104	same activity as operating year			
Emissions, lb/hr		28.26	0.174	26.60	1.520
Emissions, tpy		1.47	0.009	1.38	0.08
Crew Boat (90% engine load on mains; 50% on gens)					
Hours/yr	436	6 trips/wk during startup plus 2 rt/berthing			
Emissions, lb/hr		2.57	0.016	2.52	0.144
Emissions, tpy		0.561	0.004	0.548	0.03
Vessel Activity at FSRU (FW2)					
LNG Carrier (4.42% engine load)					
Hours/yr	1337	based on 82 berthings during startup yr			
Emissions, lb/hr		6.43	2.24E-03	4.52	0.283
Emissions, tpy		4.3	1.50E-03	3.0	0.2
Assist Tugs (10% engine load on mains; 50% on gens)					
Hours/yr	8419	same activity as operating year			
Emissions, lb/hr		5.61	0.035	5.36	0.31
Emissions, tpy		23.6	0.1	22.6	1.3
Crew Boat (19% engine load on mains; 50% on gens)					
Hours/yr	1090	6 trips/wk during startup plus 2 rt/berthing			
Emissions, lb/hr		0.61	0.004069	0.68	0.03921
Emissions, tpy		0.333	0.002	0.37	0.02
Vessel Activity Between FSRU and Federal Waters Boundary (FW3)					
LNG Carrier (48% engine load)					
Hours/yr	377	based on 82 berthings during startup yr			
Emissions, lb/hr		69.84	0.02	49.36	3.08
Emissions, tpy		13.2	0.005	9.3	0.6
Assist Tugs (45% engine load on mains; 50% on gens)					
Hours/yr	163	same activity as operating year			
Emissions, lb/hr		24.94	0.15	23.49	1.34
Emissions, tpy		2.0	0.0	1.9	0.1
Total Emissions in Federal Waters					
Assist Tugs		27.1	0.17	25.9	1.5
Crew Boat		0.9	0.01	0.9	0.1
LNG Carrier		17.5	0.01	12.3	0.8
Total		45.5	0.18	39.1	2.3

Release Parameters for Support Vessels During the Startup Year

Release Parameter	Units	Tug Supply	Crew Boat	Small LNG Carrier
Fuel	Type	Diesel	Diesel	Dual Fuel
Total Engine Rating	BHP	15000	1500	44253
Average Load	percent	30%	47%	14%
Heat Input	mmBTU/hr	32.7	5.1	39.42
Wet Fd Factor	wscf/mmBTU	10,320	10,320	10608
Oxygen Content	percent	15%	15%	15%
Exhaust Temperature	Deg F	800	800	800
Effective Stack Diameter	inches	30.6	13.0	31.5
Stack Height	feet	29.5	16.4	144.4
Stack Area	sq. ft.	5.11	0.92	5.41
Stack Flow	wscf/min	19,938	3,124	24,688
Stack Flow	wacf/min	47,579	7,454	58,916
Stack Velocity	ft/min	9,316	8,087	10,890
	ft/sec	155	135	182
	mph	105.87	91.89	123.75
Release Height	meters	9.000	5.000	44
Eff Release Diameter	meters	0.78	0.33	0.80
Release Velocity	meters/sec	47.3	41.1	55.3
Release Temperature	degrees K	700	700	700

Total Engine Rating is total rating of all vessel engines.

Effective stack diameter is equivalent diameter of 4 tug supply stacks.

Heat input is average hourly heat input based on average load on main engine(s) while operating in District waters.

Stack Parameters for Vessel Activity
During the Startup Year

	Effective Stack Diam, m	Stack Height, m	Exh Temp, Deg K	Exhaust Flow, m3/s	Exhaust Velocity, m/s	Emission Rate, g/s NOx	SO2	CO	PM10
Averaging Period: 1 hour									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	1.049	6.462E-03	0.990	n/a
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	0.077	4.914E-04	0.079	n/a
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	1.780	1.095E-02	1.676	n/a
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	0.162	1.015E-03	0.158	n/a
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	0	0	0	n/a
LNG Carrier FW2	0.800	44.000	699.67	27.81	55.303	0	0	0	n/a
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	0	0	0	n/a
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	0	0	0	n/a
LNG Carrier FW3	0.800	44.000	699.67	27.81	55.303	0	0	0	n/a
Averaging Period: 3 hours									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	n/a	4.308E-03	n/a	n/a
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	n/a	3.276E-04	n/a	n/a
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	n/a	7.299E-03	n/a	n/a
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	n/a	6.765E-04	n/a	n/a
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	n/a	1.460E-03	n/a	n/a
LNG Carrier FW2	0.800	44.000	699.67	27.81	55.303	n/a	0	n/a	n/a
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	n/a	1.709E-04	n/a	n/a
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	n/a	0	n/a	n/a
LNG Carrier FW3	0.800	44.000	699.67	27.81	55.303	n/a	0	n/a	n/a
Averaging Period: 8 hours									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	2.624E-01	n/a	2.476E-01	n/a
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	2.015E-02	n/a	2.062E-02	n/a
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	8.901E-01	n/a	8.378E-01	n/a
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	8.102E-02	n/a	7.923E-02	n/a
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	0.442	n/a	0.422	n/a
LNG Carrier FW2	0.800	44.000	699.67	27.81	55.303	0.000	n/a	0	n/a
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	4.812E-02	n/a	5.331E-02	n/a
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	0	n/a	0	n/a
LNG Carrier FW3	0.800	44.000	699.67	27.81	55.303	0	n/a	0	n/a
Averaging Period: 24 hours									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	n/a	5.385E-04	n/a	4.719E-03
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	n/a	4.299E-05	n/a	3.956E-04
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	n/a	1.825E-03	n/a	1.596E-02
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	n/a	1.691E-04	n/a	1.515E-03
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	n/a	3.832E-03	n/a	3.385E-02
LNG Carrier FW2	0.800	44.000	699.67	27.81	55.303	n/a	0	n/a	0
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	n/a	1.068E-04	n/a	1.029E-03
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	n/a	0	n/a	0
LNG Carrier FW3	0.800	44.000	699.67	27.81	55.303	n/a	0	n/a	0
Averaging Period: Annual									
Assist Tugs DW	0.777	9.000	699.67	22.45	47.327	6.262E-03	3.868E-05	n/a	3.403E-04
Crew Boat DW	0.330	5.000	699.67	3.52	41.081	4.012E-03	2.568E-05	n/a	2.363E-04
Assist Tugs FW1	0.777	9.000	699.67	22.45	47.327	4.227E-02	2.600E-04	n/a	2.274E-03
Crew Boat FW1	0.330	5.000	699.67	3.52	41.081	1.613E-02	1.010E-04	n/a	9.047E-04
Assist Tugs FW2	0.777	9.000	699.67	22.45	47.327	0.679	4.209E-03	n/a	3.718E-02
LNG Carrier FW2	0.800	44.000	699.67	27.81	55.303	0.124	4.309E-05	n/a	5.433E-03
Crew Boat FW2	0.330	5.000	699.67	3.52	41.081	9.581E-03	6.380E-05	n/a	6.147E-04
Assist Tugs FW3	0.777	9.000	699.67	22.45	47.327	5.858E-02	3.604E-04	n/a	3.154E-03
LNG Carrier FW3	0.800	44.000	699.67	27.81	55.303	0.379	1.325E-04	n/a	1.671E-02

Stack Parameters for Vessel Activity
During the Startup Year

	Effective Stack Diam, ft	Stack Height, ft	Exh Temp, Deg F	Exh Flow Rate, ft3/m	Exhaust Velocity, ft/s	Emission Rate, lb/hr NOx	SO2	CO	PM10
Averaging Period: 1 ho									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	8.33	5.1E-02	7.86	n/a
Crew Boat DW	1.08	16.4	800	7,454	134.8	0.61	3.9E-03	0.62	n/a
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	14.13	8.7E-02	13.30	n/a
Crew Boat FW1	1.08	16.4	800	7,454	134.8	1.29	8.1E-03	1.26	n/a
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	0.00	0.0	0.00	n/a
LNG Carrier FW2	2.63	144.4	800	58,916	181.4	0.00	0.0	0.00	n/a
Crew Boat FW2	1.08	16.4	800	7,454	134.8	0.00	0.00	0.00	n/a
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	0.00	0.00	0.00	n/a
LNG Carrier FW3	2.63	144.4	800	58,916	181.4	0.00	0.00	0.00	n/a
Averaging Period: 3 hou									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	n/a	3.42E-02	n/a	n/a
Crew Boat DW	1.08	16.4	800	7,454	134.8	n/a	2.60E-03	n/a	n/a
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	n/a	5.79E-02	n/a	n/a
Crew Boat FW1	1.08	16.4	800	7,454	134.8	n/a	5.37E-03	n/a	n/a
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	n/a	1.2E-02	n/a	n/a
LNG Carrier FW2	2.63	144.4	800	58,916	181.4	n/a	0.0	n/a	n/a
Crew Boat FW2	1.08	16.4	800	7,454	134.8	n/a	1.4E-03	n/a	n/a
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	n/a	0.0	n/a	n/a
LNG Carrier FW3	2.63	144.4	800	58,916	181.4	n/a	0.0	n/a	n/a
Averaging Period: 8 ho									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	2.08	n/a	1.97	n/a
Crew Boat DW	1.08	16.4	800	7,454	134.8	0.16	n/a	0.16	n/a
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	7.0646	n/a	6.649	n/a
Crew Boat FW1	1.08	16.4	800	7,454	134.8	0.64	n/a	0.63	n/a
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	3.51	n/a	3.35	n/a
LNG Carrier FW2	2.63	144.4	800	58,916	181.4	0.00	n/a	0.00	n/a
Crew Boat FW2	1.08	16.4	800	7,454	134.8	0.38	n/a	0.42	n/a
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	0.00	n/a	0.00	n/a
LNG Carrier FW3	2.63	144.4	800	58,916	181.4	0.00	n/a	0.00	n/a
Averaging Period: 24 h									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	n/a	4.3E-03	n/a	3.7E-02
Crew Boat DW	1.08	16.4	800	7,454	134.8	n/a	3.4E-04	n/a	3.1E-03
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	n/a	1.4E-02	n/a	1.3E-01
Crew Boat FW1	1.08	16.4	800	7,454	134.8	n/a	1.3E-03	n/a	1.2E-02
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	n/a	3.0E-02	n/a	2.7E-01
LNG Carrier FW2	2.63	144.4	800	58,916	181.4	n/a	0.0E+00	n/a	0.00
Crew Boat FW2	1.08	16.4	800	7,454	134.8	n/a	8.5E-04	n/a	8.2E-03
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	n/a	0.0E+00	n/a	0.00
LNG Carrier FW3	2.63	144.4	800	58,916	181.4	n/a	0.0E+00	n/a	0.00
Averaging Period: Ann									
Assist Tugs DW	2.55	29.5	800	47,579	155.3	0.05	3.1E-04	n/a	2.70E-03
Crew Boat DW	1.08	16.4	800	7,454	134.8	0.03	2.0E-04	n/a	1.88E-03
Assist Tugs FW1	2.55	29.5	800	47,579	155.3	0.34	2.1E-03	n/a	1.80E-02
Crew Boat FW1	1.08	16.4	800	7,454	134.8	0.13	8.0E-04	n/a	0.01
Assist Tugs FW2	2.55	29.5	800	47,579	155.3	5.39	3.3E-02	n/a	0.30
LNG Carrier FW2	2.63	144.4	800	58,916	181.4	0.98	3.4E-04	n/a	0.04
Crew Boat FW2	1.08	16.4	800	7,454	134.8	0.08	5.1E-04	n/a	0.00
Assist Tugs FW3	2.55	29.5	800	47,579	155.3	0.46	2.9E-03	n/a	0.03
LNG Carrier FW3	2.63	144.4	800	58,916	181.4	3.00	1.1E-03	n/a	0.13